NOTES ON THE TERRESTRIAL ECOLOGY OF THE FIVE ISLANDS. I.

By Consett Davis, M.Sc., Linnean Macleay Fellow of the Society in Zoology;
M. F. Day, B.Sc.; and D. F. Waterhouse, B.Sc.
(*From the Zoology Department, Sydney University.*)

(Plates xv–xix; eight Text-figures.)

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Introduction.

The absence of any synecological study of the plant and animal complex (biome) of a terrestrial community in Australia has made impossible the practical illustration in this country of certain well-known ideas, which form the basic principles of animal ecology. In particular, this lack has handicapped the teaching of animal ecology, and has prevented the subject receiving the attention which it merits. With this in mind, the present survey was undertaken rather with a view to illustrate general principles with local examples than to develop any special theory.

The Five Islands, near Port Kembla, N.S.W., were chosen as the location for this survey, because certain factors peculiar to islands appeared to be intrinsically interesting, and also because it was hoped that the terrestrial life of these islands represented a more or less self-contained unit. Belief that we were dealing with a microcosm was soon shattered, and in this paper are set out the numerous ways in which the chosen area fails to represent a 'closed' community. It is certain, however, that these interactions with extraneous communities are far less numerous than would be the case if a mainland area had been selected.

In this paper are discussed the geological and physiographical history of the islands; the climate; the plant ecology; and the various ways in which the islands fail to represent 'closed' communities. The departure from the ideal closed community is due to products of littoral and pelagic communities, and of terrestrial communities from the mainland, becoming involved in the food-chains of the terrestrial life of the islands. Habitats for terrestrial animals, other than those embraced by communities of vascular plants, are also listed. Subsequent papers will comprise lists of all animals collected, with notes on habitat, numbers, food and enemies; from these lists it is hoped that food-chains may be deduced. Later it may be possible to compare these islands with other coastal islands.

General Description of the Five Islands.

Figure 1 shows the general disposition and size of the islands, which we have designated I–V, referring to each island subsequently by the number alone. Certain features are named on Figure 2, the names being bestowed by us for convenience. I, known locally as Big Island or Rabbit Island, is 30 acres in extent, and reaches a height of 71 feet;[1] it is separated from the mainland at Red Point by only 500 yards, with a reef in intermediate position. Communities of vascular plants[2] occupy 57% of **I**. **II** lies to the east of **I**, and is connected thereto by a low isthmus, wave-swept at high tide during rough weather. **II** is 18 acres in extent, 49 feet at the highest point, with 45% covered by vascular plant communities. On some maps it is marked as Perkins Island. **III**, which lies less than 150 yards south-east of **II**, is 6 acres in extent, 53 feet at the highest point, with only 14% of its area occupied by communities of vascular plants, which are confined to the higher parts of its western half. **IV**, about 2 miles north of **I**, and 1¾ miles from the nearest point of the mainland, is 7 acres in extent, 43 feet at the highest point, with 15% of its area occupied by vascular plant communities. It is the island most sheltered

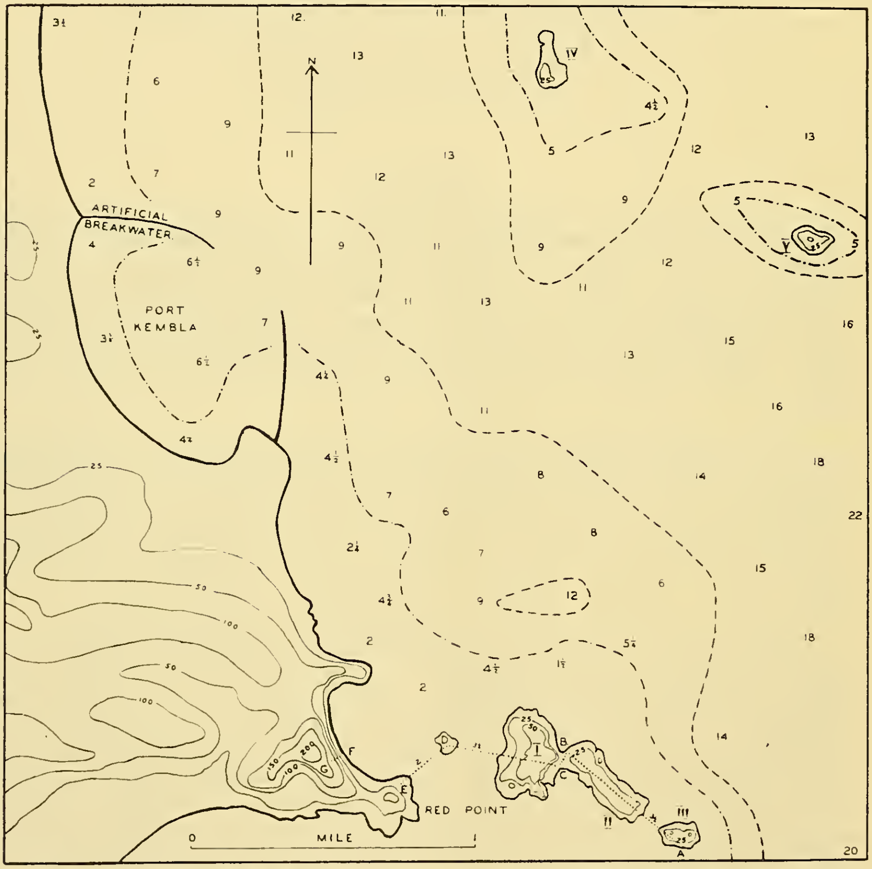

Fig. 1.—Map of the Five Islands (I-V) and surrounding parts, with contours (25-ft., 50-ft., thence at 50-ft. intervals), and ocean soundings (fathoms, low tide). A-B-C-D-E, F-G, line of section for Fig. 6. D represents Midway Reef. —·—·—·—, Approximate position of 5-fathom isobath. — — — — — — —, Approximate position of 10-fathom isobath.

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[1] Heights are reckoned from mean tide level, areas as those exposed at mean tide level.

[2] All vascular plant communities, including the sparse *Scirpus nodosus* community, with low percentage cover, are included in this figure.

from southerly storms, which produce the heaviest seas to which the islands are subjected. V, the most exposed island, which lies 1 mile to the south-east of IV and 2 miles from the nearest part of the mainland, is 5½ acres in extent, 52 feet at the highest point, with about 3% covered by vascular plant communities. IV and V are referred to on most charts as the Tom Thumb Islands.

In Figure 1 are also indicated 25- and 50-feet contours, and soundings near the islands, with 5- and 10-fathom isobaths. Figures 2–4 give detailed (10-ft.) contours; those on I–IV are fairly accurate, the heights having been surveyed with pole and level and plotted in the field on vertical aerial photographs (scale 10·56 inches to the mile). The contours on V are to be regarded as form-lines, constructed, with the aid of aerial photographs, from a knowledge of the maximum height of the island (obtained trigonometrically), and its profile from several different aspects. Only a few short visits have been made to V, which is difficult of access.

Vertical aerial photographs of the islands are given in Plate xv (from 5,000 ft.), and, for I–III and the coast adjacent, in Plate xvi (from 12,000 ft.). The photographs comprising Plate xv were taken with the sun in approximately north-eastern position, while in Plate xvi the sun was approximately north-west. Shadows indicate various topographic features.

HISTORICAL.

The Five Islands were observed by Cook in 1770, and by Bass and Flinders in 1793. The former charted three islands, apparently mistaking I and II for part of the mainland; this error is easily made from the seaward side, and Cook's name, Red Point ('Some part of the Land about it appeared of that Colour') obviously derives from the colour of the rocks on the south side of I and II, although the name is now applied to the adjacent mainland, where it is quite inapt. Bass and Flinders noted four islands, apparently overlooking III. In these and other early journals we have found no descriptions of any value to the present study, e.g., information whether the dune covering of I was then present or, as now, blown off and existing as sand-drifts on the sloping sides of the islands.

The following facts have been ascertained from Port Kembla residents, as occurring within their memory: About 50 years ago, the Perkins family lived on I for several years. From this time dates the introduction of rabbits and goats[3] to I and II, and possibly also the introduction of the Buffalo Grass, *Stenotaphrum secundatum* (Walt.) Kuntze (= *S. americanum* Schr.) to I. Prior to this occupation, a Wollongong resident was in the habit of fattening young cattle, several at a time, on I and II. The rabbits, whose stock may have been augmented from without since the original introduction, are still present, though kept in check by birds of prey, and also by occasional shooting parties from Port Kembla. The goats, though established for many years, were killed off about 1917 by visiting parties.

In more recent years, I and II have been visited occasionally by camping parties, and IV very rarely. III and V are seldom, if ever, visited. The work of officers of the Prickly Pear Destruction Commission on I, II, III and IV is mentioned under the heading of Plant Ecology.

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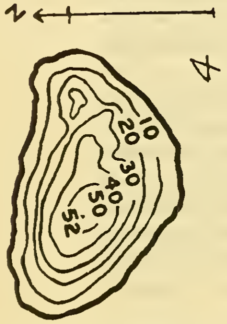
[3] In an early work, 'Our Antipodes', by Colonel Mundy (London: Richard Bentley, 1852), there is a reference to a visit to Rabbit Island (I) in 1849. It is noted that rabbits and goats had been present on this island for several years. There is no means of finding out whether descendants of these were still present when the later introductions occurred. No reference is made in this book to the state of erosion of the sand cover of the island.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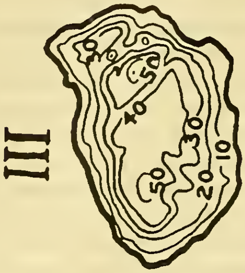
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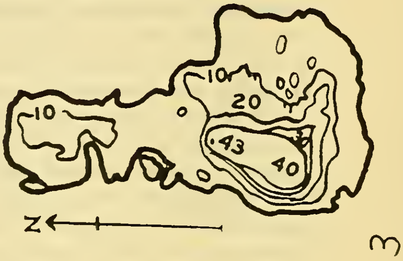
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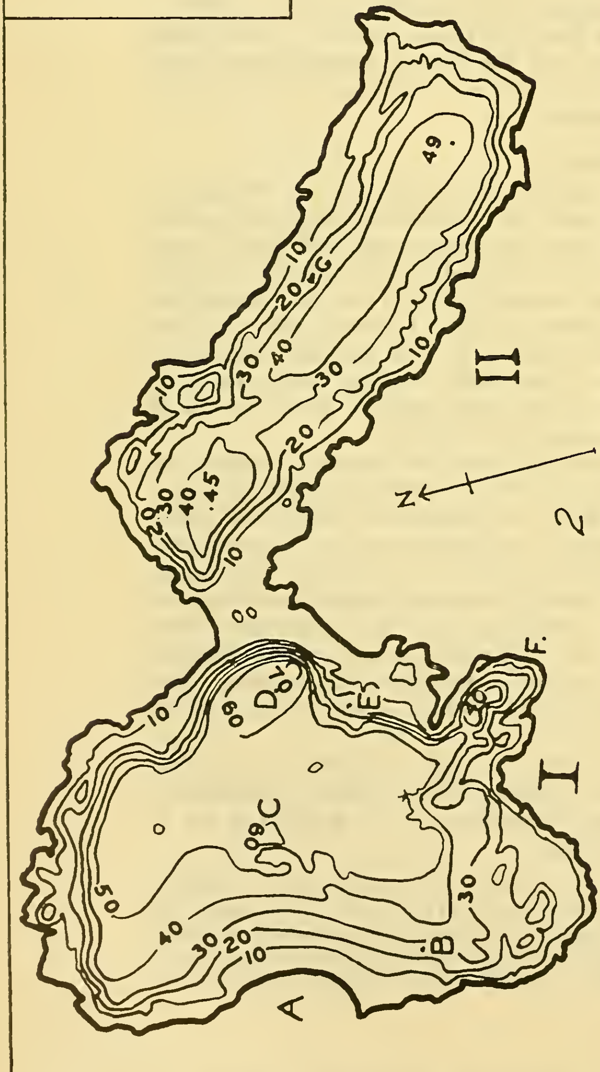
II
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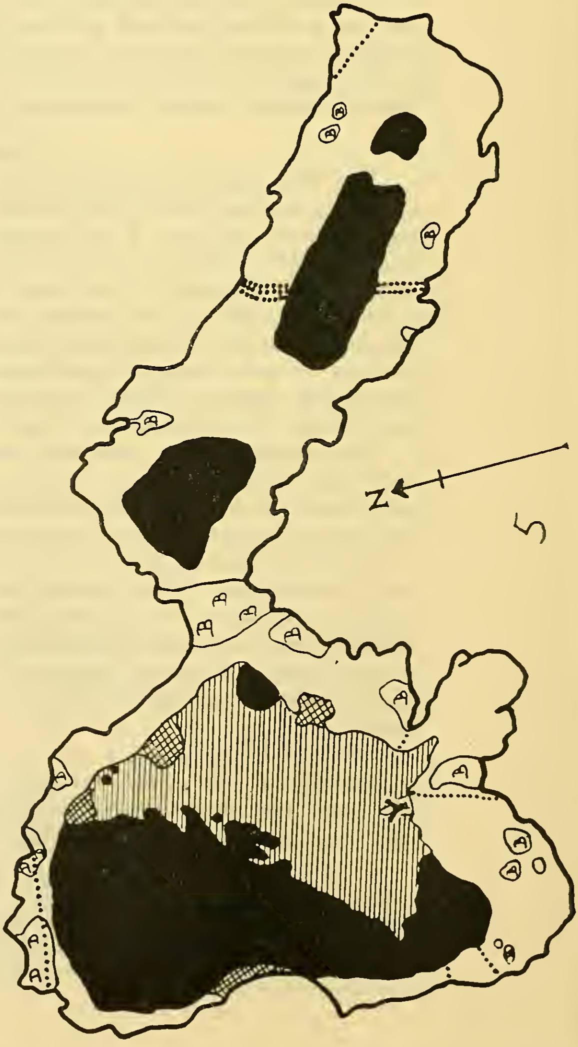
A
B
N
5

Reports of Port Kembla residents indicate that no trees have been growing on any of the islands, and that the dune covering of I has been more or less in its present state during the last 50 years. It is probable that the islands never supported trees at any time.

GEOLOGY.

Islands I, II, III and V are composed of Dapto-Saddleback Dolerite, which Harper (1915) considers to be a submarine flow of Upper Permian age. The evidence for this is that the dolerite, which lies above sedimentary rocks of the Upper Marine series, is overlaid in the Albion Park district by rocks of similar age containing marine fossils. The dolerite forms an extensive flow on the mainland, the islands being almost certainly remnants of this continuous flow. The lower level of the dolerite—that is, its junction with Upper Marine sedimentary rocks—is of irregular horizon; thus, although the dip of the Upper Marine and all other strata in this district is to the north and west, the lower limit of the dolerite is concealed below sea-level on I, II, III and V, but is more than 50 feet above sea-level at Red Pt., immediately to the east of I. Midway Reef, between I and Red Pt., is composed of Upper Marine argillaceous sandstone, reaching about eight feet above mean tide level; the dolerite has here been removed by erosion, but its lower level must have been above this height. These levels are indicated on Figure 6. They may be explained by faulting, or (as in Fig. 6) by an irregular surface for the Upper Marine at the time of extrusion of the dolerite. The latter sequence is more probable, although, if we follow Harper, this irregularity could only have been due to submarine erosion. The fact that the lower level of the dolerite is below sea-level on the mainland less than a mile north of Red Pt., i.e. lower than the dip of the underlying strata would account for, supports the view that the dolerite was poured out on an irregular surface. An alternative possibility is that the dolerite is not a flow, but an irregular sill. The possibility of small faults between Midway Reef and I, and between III and V, cannot be ruled out entirely, but defies proof, as the critical points are submerged.

The distribution of the different forms of dolerite on I and II is illustrated in Figure 5. The normal rock corresponds to Type A of Browne and White (1929, Fig. 1),[4] whilst variants corresponding to Types B and D of these authors also occur on I and II. These variants seem to weather more readily than the normal type. The isthmus between I and II is composed of Type B, which possibly also occurs (submerged) between II and III. Wherever the variants occur elsewhere they are associated with ravines, inlets or large rock-pools. Tertiary basic dykes are also present on I and II, and appear to be zones of more rapid weathering.

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[4] In this paper the nature of the so-called Dapto or Saddleback Dolerite is discussed; it should be termed rather a trachy-basalt.

Fig. 2.—Map of Islands **I-III**, with 10-ft. contours. Scale 10 inches to the mile. Place-names given for reference purposes: A, The Beach; B, Freshwater Springs; C, Camp Hummocks; D, High Hummock; E, Phragmites Soak; F, Periwinkle Point; G, Triangle Pool.

Fig. 3.—Map of Island **IV**, with 10-ft. contours. Scale 10 inches to the mile.

Fig. 4.—Map of Island **V**, with approximate 10-ft. contours. Note: Heights are reckoned from mean tide level in Figs. 2, 3 and 4.

Fig. 5.—Geological map of Islands **I** and **II**. Scale 10 inches to the mile. Plain white, normal type (A) of Dapto dolerite; white with 'B' and 'D', dolerite, Types B and D respectively (see text); dotted lines, dykes; black, dune sand fixed by vegetation; cross-hatched, loose sand; horizontal shading, recent sandstone; 'Y', clay soil below sandstone, exposed by weathering of latter.

Triangle Pool, a large pool just under 30 feet above mean tide level, is closely associated with the dykes diagonally crossing the eastern part of II, and the ravine on I north-east of Periwinkle Pt. is due to the weathering of a dyke in this position.

The dolerite of III and V is entirely of the normal type (A). In all parts the dolerite, in addition to the effects of differential weathering of its local forms, is of very irregular surface, being criss-crossed with large cracks, due to weathering along joint-planes (Pl. xv, xvi and xix, D, F and H). The ravines of III, and at least portion of that on the north side of II near the western end, are associated neither with any variation from the normal type of dolerite, nor with dykes.

There is little evidence on I, II, III and V of raised rock-platforms, such as are found in shales on adjacent parts of the coast. This may possibly be due to the resistant nature of the normal dolerite. In most places the dolerite slopes moderately steeply and smoothly into the sea, save for irregularities due to natural fracture, or differential weathering of the altered forms (B and D, *supra*).

Overlying the dolerite on the top of I and II is a cover of dune sand, thick on I, thin on II. This is in the form of residual hummocks, especially on I, suggesting partial removal, as detailed in the next section. The lower areas between hummocks on I are composed of a very soft recent dune-sandstone, somewhat weathered, below which a heavy clay soil is exposed in a few places. In our opinion, the original dune cover of I and II could not have formed with the sea-level in its present relation to the doleritic rocks of the islands.

IV is composed of trachy-andesite, apparently the only remnant of a local flow. The northern half of the island and the eastern parts of its southern half form a low rock-platform, mostly less than 10 feet high. The western part of the southern half of the island forms a plateau reaching more than 40 feet in height, with steep sides, except to the south-east, where the rock slopes more gently to the platform.[5] In the sides of the plateau, especially near the north-eastern corner, caves are present up to about 25 feet above mean tide level; these are probably due to differential weathering of variants from the normal rock type, rather than to wave action at a period of higher sea-level.

PHYSIOGRAPHIC SEQUENCE.

The physiographic sequence leading to the separation of the islands may be followed from the time of the completion of the Kosciusko Uplift, probably of the order of one million years ago. At this period faulting possibly occurred between Midway Reef and I, and between III and V. From the time of the uplift, the rocks of this district have been subjected to continuous rapid erosion, resulting in the formation of a coastal plain, at present some 7 miles wide in this district (Davis, 1936*b*, and papers quoted therein). On this plain, the more resistant igneous rocks which now form the islands would, at a period of low sea-level, have been isolated elevations, comparable with the two hillocks of dolerite now existing on the plain just behind Port Kembla (represented by 25-ft. contours on Fig. 1). Neglecting earlier fluctuations in sea-level, and considering only those of the most recent cycle, we find that some 25,000 years ago the sea-level was universally about 250 feet lower than at present, and that, up to about 3,000 years ago, a gradual eustatic rise occurred to a height some 15 feet above the present level.

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[5] For the profile afforded from sea-level looking south-east, see Davis, 1936*a*, Pl. xii, 1.

Within the last 3,000 years the level has fallen some 15 feet (Daly, 1934). The application of these changes to the New South Wales coast is generally accepted.[6]

During the process of drowning, then, some 8,000–10,000 years ago, IV and V, at that time hillocks on the coastal plain, were severed from the mainland. The times of severance of I, II and III are more difficult to fix accurately, as moderately rapid erosion is still no doubt proceeding on the isthmus between I and II, and in the shallow water between II and III and between I and Red Pt. It is probable that drowning separated these islands about 4,000 years ago, and that during the 15-ft. fall in the last 3,000 years marine erosion has maintained the depth of intervening water, compensating for the falling level.

This sequence indicates that the islands have been continuously habitable for terrestrial communities such as occupy them at present, since the times of their separation from the mainland.[7] With sea-level 10–15 feet higher than at present (as at 3,000 years ago), V, in its present form, would be barely habitable, while the habitable areas of the other islands would be decreased. The probable decrease in the extent of the rocks forming the islands since the time of maximum sea-level would, however, allow V clearance above sea-level at all times sufficient to support terrestrial vegetation. This is supported by a consideration of the fauna of V, including lizards, Myriapods, etc. IV, though lower than V, would not be rendered uninhabitable by a rise in sea-level of 15 feet, even in relation to its present size, since it is more sheltered from heavy seas.

There is, therefore, no need to postulate that the native plants and wingless animals of the islands are other than relict from the time of severance, although it is possible that some are not lineal descendants of the population at that time, but are more recent colonists.

Prior to the drowning of the land around I–III, undulating sand-dunes, directly continuous with those now present on and to the south of Red Pt., probably covered this area. With the onset of drowning, most of this sand was washed away, leaving a thick cap on I and a thin covering on II (as indicated in Fig. 6, including the contour of the dotted lines), and cutting away the smooth slope of the dune on Red Pt., to give the present form. Below the level of the old dunes, usually at a depth of six feet or more, the sand was bound together to form a very soft sandstone. The binding substances appear to be hydrated oxides of iron, with little or no calcium carbonate. This recent sandstone may be regarded as a compacted illuvial horizon, the great porosity of the sand placing this horizon at a lower level than that normally found in other soils of this climatic zone, where podsols are the prevailing type. The recent sandstone is exposed in some places on the slopes of Red Pt., but is covered in most places by the loose sand talus.

In comparatively recent times, part of the sand covering of I and II has been removed by wind action, as indicated in Figure 6. Some of the sand so

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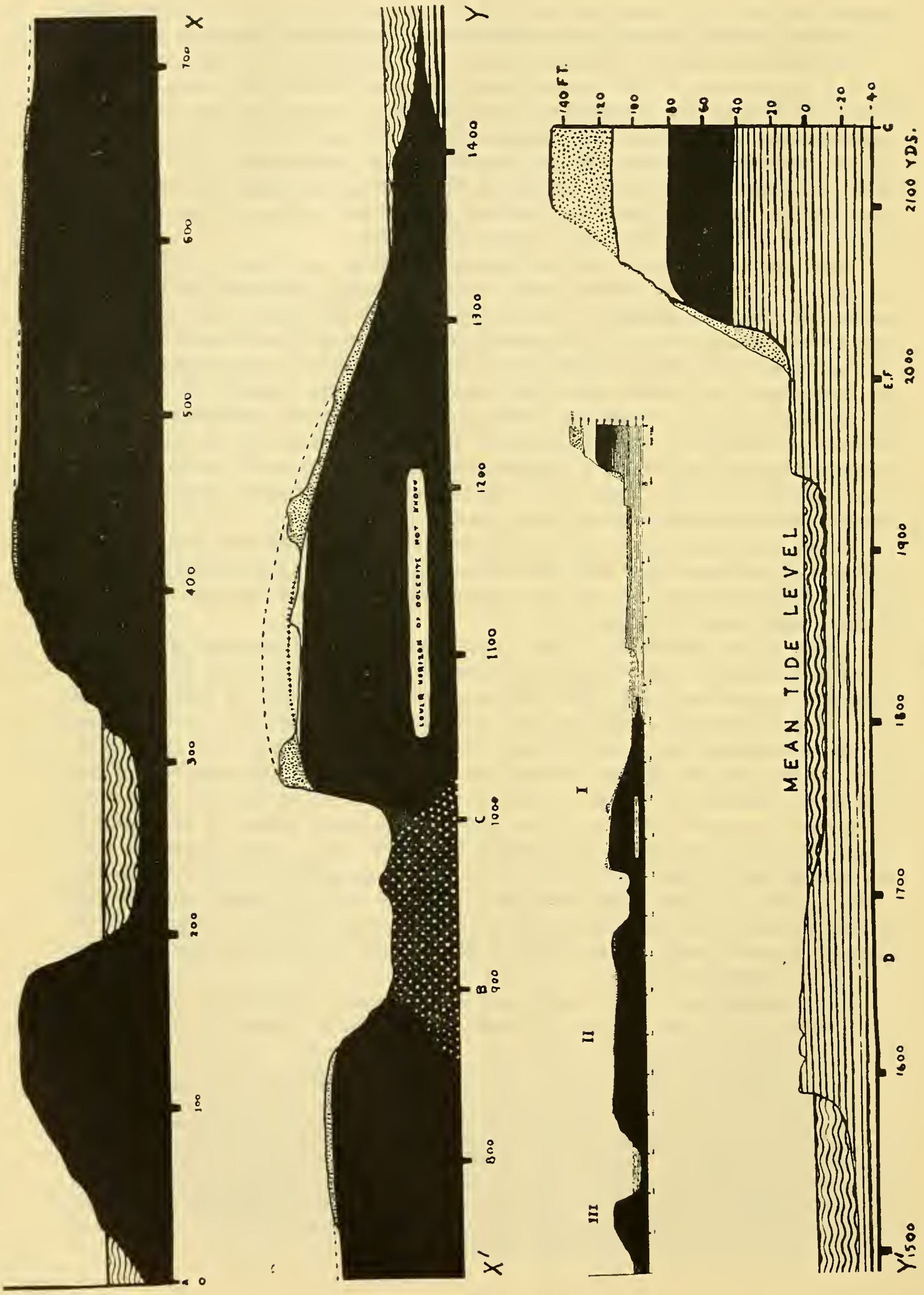
[6] See also Cotton (1926).

[7] This probably applies to all the coastal islands of South-Eastern Australia. The claim that Lady Julia Percy Island, off the Victorian coast, is 'a pure volcanic mass uprisen in the sea, and not . . . a part of the old continental mass sundered from the mainland' (McCoy Society Report, 1937, p. 329) does not seem to be supported by any sound positive evidence. This island is separated from the mainland by about 4 miles of water, up to about 20 fathoms deep. To support the above claim, one must postulate a large and very recent uplift for this sector of the coast, or an improbably recent time for the vulcanicity responsible for the island rocks, with great subsequent reduction in the extent of the flows in a very short period.


X
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A
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1200
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X'
LOWER HORIZON OF DOLERITE NOT KNOWN
140 FT.
120
100
80
60
40
20
0
-20
-40
G
2100 YDS.
E.F
2000
1900
1800
1700
D
1600
Y'
1500
MEAN TIDE LEVEL
I
II
III

Fig. 6.

removed is now present as bare drifts on the northern slopes of I (Pl. xvii, C), and as a drift, partly stabilized by plants, on its south-eastern slopes. The removal of this sand from II, where its former thickness was not great enough to lead to the formation of underlying sandstone, has laid bare the dolerite; on I the recent sandstone has been exposed. This has weathered to some extent, leaving an irregular surface with local elevations (Fig. 6; Pl. xvii, D). Erosion on the southern side of the exposed sandstone area of I has produced small ravines (Pl. xvii, E, F), revealing in a few cases an underlying heavy clay soil. This was probably derived from the dolerite, pre-dating the covering of this district by dunes. Its texture suggests that it is to be regarded as a 'Y' horizon,[8] the illuvial horizon of a pre-existing soil; the eluvial ('X') horizon has partly been removed by erosion, together with the overlying sandstone, partly become identified with the latter. This old soil is not represented in Figure 6, the sandstone probably resting direct on the dolerite on the section line. It seems to occur only under the southern part of the sandstone tract, where the pre-existing soil had evidently accumulated in a concavity in the surface of the dolerite. More of this clay horizon is continually being exposed by erosion following rain, small ravines cutting back into the 'blow-out' area due to the softer nature of the clay and consequent under-cutting of the sandstone. Both the clay of this 'Y' horizon and also the recent sandstone above it are unsuitable for plant growth, being hard and practically devoid of humus.

The cause and date of the 'blow-out' of the sand covering of I and II are somewhat problematical. The erosion of the underlying elements on I gives some evidence of the date, suggesting possibly several hundred years ago. The hummocks of sand on I are held in place by the introduced Buffalo Grass, and the sand-drifts on the slopes appear to be unstable and in the process of disappearance; but the tempting hypothesis that the 'blow-out' was caused, after the colonization of the islands by Buffalo Grass, by clearance of the stabilizing vegetation by rabbits, must be abandoned, because of the extent of erosion of the underlying formations and the fairly definite information of Port Kembla residents. We must assume that the 'blow-out' occurred before the advent of Europeans, and introduced plants and animals; that the hummocks of sand at the old level were held, at the time of 'blowing-out' of the surrounding sand, by indigenous vegetation (possibly *Sporobolus virginicus* and *Lomandra longifolia*); that this vegetation has now been largely replaced by Buffalo Grass, which has been able to cross the barren areas of exposed sandstone; and that the sand-drifts on the slopes are more stable than first inspection would suggest. The original 'blow-out' may have been caused by wind acting on sand whose vegetational cover had been disturbed by burrowing

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[8] For the use of the terms 'X' and 'Y' horizon, see Macdonald Holmes, 1937.

Fig. 6.—Ideal section along line A-B-C-D-E, F-G of Fig. 1, V/H = 3/1. Camp Hummocks projected on section plane between C and D; section carried from E to a point of similar elevation and formation at F, to show formations behind F, which have been denuded behind E and would be omitted by a section continuing from D past E in a straight line.

The section is given in three pieces, X adjoining with X′, Y with Y′. A small-scale reproduction of the whole section is given.

Horizontal shading, Upper Marine sedimentary rock; black, normal type of Dapto dolerite; white stippling on black, Dapto dolerite, Type B (see text); plain white, recent sandstone; black stippling on white, dune sand; undulating lines, ocean water; — — — — —, contour of old surface of dune, before 'blow-out'; + + + + + +, contour of former upper horizon of recent sandstone, before weathering following 'blow-out' of dune.

marine birds; this process seems to be going on at present on parts of I where the sand cover is still present, and is detailed in the section on plant ecology.

III, IV and V show no indication of former sand cover. The soil of V is shallow and restricted to hollows in the rock on the higher parts of the island; that of III is fairly shallow, and confined to the upper portion of the western end. Both are derived from the dolerite, the latter with a slight admixture of sand particles, probably wind-borne. The plateau of IV possesses a good soil of fine texture, derived from the underlying trachy-andesite. It is at least two feet deep at the centre of the plateau, with definite podsolization, and becomes shallower towards the edge. Considering its size, the vegetation of IV is the richest of the group. This is doubtless attributable to better soil properties, the soil not being shallow and scarce, as on III and V, nor masked by poor dune soil, as on I and II. The shallow sand covering of II is probably in part mixed with soil originating from decomposition of the dolerite.

CLIMATE.

Temperature, humidity and rainfall data for Wollongong have been given by Davis (1936*b*). The averages are: Maximum daily temperature 71·4° F.; minimum daily temperature 54·6° F.; relative humidity 73%; annual rainfall 45·65 inches. The rainfall at the islands is probably somewhat less than at Wollongong. Our observations indicate that the islands miss many showers which strike Wollongong and other points on the coast, and this is supported by theoretical considerations. The mountains behind Wollongong, and behind the coastal plain in general, precipitate the rain, and proceeding east from these mountains to Wollongong there is an observed drop in rainfall, which is probably continued seawards from the coast.

The temperatures detailed are shade temperatures. The terrestrial life of the islands is subjected to much greater extremes. Our observations indicate that the daily range in exposed situations such as the more open parts of the *Scirpus nodosus* community on I may be very considerable.

All the islands are very exposed to winds, V most and IV least so. The question whether this justifies the recognition of shrub communities as a climatic climax for the islands is dealt with in a subsequent section. In rough weather, salt spray is driven over all portions of the islands. We have observed fine spray drifting across the highest point of the islands (High Hummock, I, 71 ft.) in moderately rough weather; at this time, heavy spray was being driven over the whole of II and III, while V was subjected throughout to very heavy spray. Relatively high chloride contents were observed for all soils, particularly poorly-drained soils with little leaching. All plants on the islands must be considered halophiles to a greater or less degree; a large number are common to the islands and to the saline swamp vegetation of the Sydney district described by Hamilton (1919). The effects of spray on all pool communities on the islands is discussed later.

PLANT ECOLOGY.

In Table 1 are listed the various species of vascular plants observed, with notes on frequency on each island, life-form, and usual habitat. For purposes of classification we have recognized the following communities: (1) The *Correa-Westringia* Community; (2) The *Stenotaphrum* Community; (3) The *Sporobolus* Community; (4) The *Scirpus nodosus* Community; (5) The *Mesembryanthemum* Community; (6) The *Lomandra* Community; (7) The *Salicornia* Community; (8) The *Spergularia–Claytonia–Portulaca* Community; (9) The *Scirpus cernuus* Community.

This classification includes under the term 'Community' widespread aggregates such as the *Stenotaphrum* or *Correa-Westringia* communities, and small local groups such as the *Scirpus cernuus* community. Communities (6) to (9) might better be termed 'societies'. We have purposely omitted terms such as 'consociation' and 'consocies', with their successional implications; the shrub community (*Correa–Westringia*) is the highest on the islands, but even it is to be regarded as a subclimax. Certain communities (e.g., *Mesembryanthemum aequilaterale* on almost bare rock) can be regarded as seral (stages in a lithosere of which placoid lichens are the initiators); but, as, on the whole, the vegetation is in a retrograde state, due to the gradual marine erosion of the islands, etc., we do not consider that upgrade succession is proceeding to any marked extent. Apart from retrogression by marine erosion, the vegetation is in a highly unstable state, chiefly due to disturbance by man, introduced animals and plants, and burrowing sea-birds.

Plate xv*a* shows the distribution of the communities, with the exception of the *Scirpus cernuus* community, which occupies a small area on I and II, fringing the lower limit of other communities in some parts, especially along the southern side. The habitat factors of the various communities are considered as each is dealt with, but the relations of *Stenotaphrum*, *Sporobolus* and *Scirpus nodosus* may be discussed here. Plate xv*a* shows the presence of *Scirpus nodosus* community on the central part of I and a small portion of II, in those parts where the sand cover has been removed, exposing recent sandstone, hard clay, or (on II) dolerite, as detailed earlier. In the areas of sand remaining, the chief stabilizing agents are the grasses *Stenotaphrum* and *Sporobolus*. The former is introduced, the latter indigenous. The transparency (Pl. xv*a*) suggests that *Stenotaphrum*, probably introduced to the inner (western) side of I, the usual place of landing and residence by visiting parties, has displaced *Sporobolus* on I (except for a remnant on Periwinkle Pt.), and over the inner end of II. Whether this displacement is still proceeding at the ecotone cannot yet be stated with certainty; *Stenotaphrum*, however, became more prominent on II, between its eastern limit as marked on Plate xv*a*, and Triangle Pool, between August, 1937 (when the transparency was prepared), and April, 1938, and in July, 1938, appeared to be further spreading in this region at the expense of the *Sporobolus* community.

Vegetation (*Stenotaphrum* community) reaches a point slightly below the 10-ft. contour behind the beach, on I (Pl. xvii, J), the spot most sheltered from rough seas on any of the islands. Elsewhere, the lower limit of vascular plants is much higher, on I and II between 10 and 20 feet, on the western extremity of III 20 feet, and elsewhere on III 30 feet. Only a few therophytes occur below 20 feet on IV, the entire northern rock-platform being devoid of vascular plants except a few specimens of *Sonchus oleraceus*. On V, most of the vascular plants occur above the 40-ft. contour, 30 feet being the lower limit, except on the north-west corner, where more efficient shelter from south-easterly seas allows them to reach a slightly lower level.

The Correa–Westringia Community: A shrub community 3–4 feet high is developed over extensive areas of II, at the north and south ends of the plateau of IV (a few bushes also on the eastern slopes, IV), for a limited area on the slopes of the western end of III, and, as a few isolated bushes, on the north side of I. The shrubs occur only on well-drained soils, usually not less than six inches in depth. They do not seem to be limited in any way to situations sheltered from the wind. The properties of three typical soil-samples from this community are given in Table 2. The absence of shrubs from the central part of the plateau of IV cannot be explained satisfactorily. The salinity (as indicated by chloride content) is higher in the central part of the plateau, due to the run-off of water from the slightly higher parts at the north and south ends; the humus content is lower, and the pH higher. The humus content of soils in the shrub community, however, is a direct result of the conditions below the shrubs, where many fallen leaves accumulate. Similar conditions on the margins of the shrub community, where there is cover by branches but absence of rooted plants, should allow the community to spread if humus content alone were the limiting factor in shrub distribution. Neither high salinity nor high pH (a result of high salinity and low humus content) can be limiting, as the figures for a shrub community from II are higher than for soil from the centre of the plateau. No young shrubs have been present at the margins of the community on the plateau at any time since our observations commenced; indeed, some of the older bushes were wholly or partly dead (March, 1938), possibly from severe wind action, possibly from infestation by scale-insects. The factors limiting shrub distribution are not known. The burrowing activities of penguins and mutton birds adversely affect the stability of certain communities on I and II, but, in general, these birds burrow in the more open communities rather than amongst shrubs. However, some of the marginal shrubs bordering the *Mesembryanthemum* community on IV were partly undermined by penguin burrows in July, 1938, and this may possibly have an adverse effect on the roots, promoting the limitation and destruction of the shrubs at and near the centre of the plateau.

Correa alba is dominant in most parts of the shrub community of II, *Westringia rosmariniformis** seldom becoming dominant or co-dominant (Pl. xvii, G). On the plateau of IV, *Westringia* and *Correa* are co-dominant, or each attains local dominance in some areas (Pl. xvii, H), while *Myoporum ellipticum* occurs occasionally, attaining dominance in a small area near the western edge of the plateau (Pl. xvii, I). In the shrub community of III, *Correa* and *Myoporum* are co-dominant, *Westringia* absent.

On I, in the few places where shrubs develop, *Westringia* is the dominant.

The shrub communities of I and III were probably of greater extent before the advent of Europeans and the introduction of exotic plants. *Opuntia inermis*, when unchecked, grows strongly amongst the shrubs on III and parts of II. The fluctuations of *Opuntia* are discussed more fully under the *Stenotaphrum* community.

In its undisturbed state, the *Correa–Westringia* community is practically devoid of other plants. Neighbouring communities, such as *Sporobolus* on II and *Mesembryanthemum* on IV, may enter the shrub community marginally as a ground layer, and occupy the areas between the scattered bushes. In most cases, however, the shrubs grow close together, and the ground below them is devoid of any other vegetation, probably because of lack of light and the presence of an A_0 horizon of fallen leaves, an obstacle to seedling germination. On IV the climber *Kennedya rubicunda* occurs scrambling over the shrubs.

The Stenotaphrum Community, with variant facies: The introduced Buffalo Grass (*Stenotaphrum secundatum*) is dominant on sandy areas over a large proportion of I and the western end of II; it also occurs on V in shallow soil in rock crevices, not reaching the status of a community. It has recently (since 1934) colonized IV, being well established on the eastern slopes and plateau in March, 1938.

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* Since the completion of this paper, Mr. E. Cheel has recorded *Westringia fruticosa* Druce as the correct name for the species cited in this paper as *W. rosmariniformis* Sm. (Abstract, Proc. Linn. Soc. N.S.W., 31 Aug., 1938.)

The properties of soil samples from four parts of this community are given in Table 2. In Table 3 is indicated the effect of nesting of sea-birds on the nitrogen and phosphorus content of soil from this community; nitrate and ammonia content is raised, phosphate apparently not. This increase in combined nitrogen appears to have little effect on the vegetation.

The grass often reaches a height of 1–2 feet. During our earlier visits (1934–5), *Opuntia* and *Stenotaphrum* were competing for dominance in those parts of I and II where the latter is now dominant (as shown in Plate xv*a*). The two species were growing up, sometimes above three feet in height, the lower layers with a large percentage dead from lack of light, the *Stenotaphrum* tending to gain the advantage in the struggle for light, except in the more open parts, where the plants were disturbed by penguin burrows. *Opuntia* is a wide, occurring in all the communities of well-drained soils (particularly the *Sporobolus* and *Correa-Westringia* communities) and on almost bare rock. During our earlier visits it appeared to be becoming dominant in all the more open places. Particularly since 1935, officers of the Prickly Pear Destruction Commission (N.S.W. Department of Lands) have taken measures to eradicate the *Opuntia*, because segments of the cladodes were breaking off, falling into the sea, and so being carried down the coast to infect farms on the mainland to the south of the islands. This colonizing ability indicates how *Opuntia* originally reached the islands.

Opuntia has been attacked by the introduction of the eggs of the moth *Cactoblastis cactorum* Berg.; by poisoning with arsenic; and by fire. It has never been exterminated completely, as the attempted eradication measures have been somewhat sporadic, and from time to time it becomes fairly abundant. It is to be regarded as a widespread facies in most communities (especially *Correa-Westringia*, *Stenotaphrum*, *Sporobolus*, *Scirpus nodosus* and *Mesembryanthemum* communities), varying sporadically on account of the biotic factor of human interference (Pl. xviii, C, D, E).

The *Stenotaphrum* community has two other notable facies, those given by *Phytolacca octandra* and *Tetragonia expansa*. The former occupies large areas of the *Stenotaphrum* community to the north and west of I, and is a seasonal facies, *Phytolacca* being an annual. The *Tetragonia* facies is represented by a moderate area behind the beach on I, and a small area on the southern side of the west end of II. *Tetragonia* grows as a perennial on the islands, and in places occurs as an almost pure stand, with very little *Stenotaphrum* admixed. The humus content appears to be higher in the *Tetragonia* facies than elsewhere in the *Stenotaphrum* community.

Other elements of the *Stenotaphrum* community are of rarer occurrence. We have considered as a separate community *Lomandra longifolia*, which may occur alone or with *Stenotaphrum*, as at Camp Hummocks, I (Pl. xvii, A). *Phragmites communis* grows amongst *Stenotaphrum* in the southern portion of I, especially near Phragmites Soak (Pl. xix, G), in most cases in soil more efficiently drained than in its mainland habitats. *Imperata cylindrica* var. *Koenigii* and *Setaria glauca* occur in the *Stenotaphrum* community behind the beach, I, the latter as a seasonal facies. Other elements can be found by reference to the last column of Table 1, in most cases being straggling plants (e.g. *Hibbertia volubilis*, *Commelina cyanea*, *Kennedya rubicunda*), or small herbs, often annual (e.g. *Anagallis arvensis*, *Solanum nigrum*, and many Composites). The bracken (*Pteridium aquilinum*) occurs occasionally in this community.

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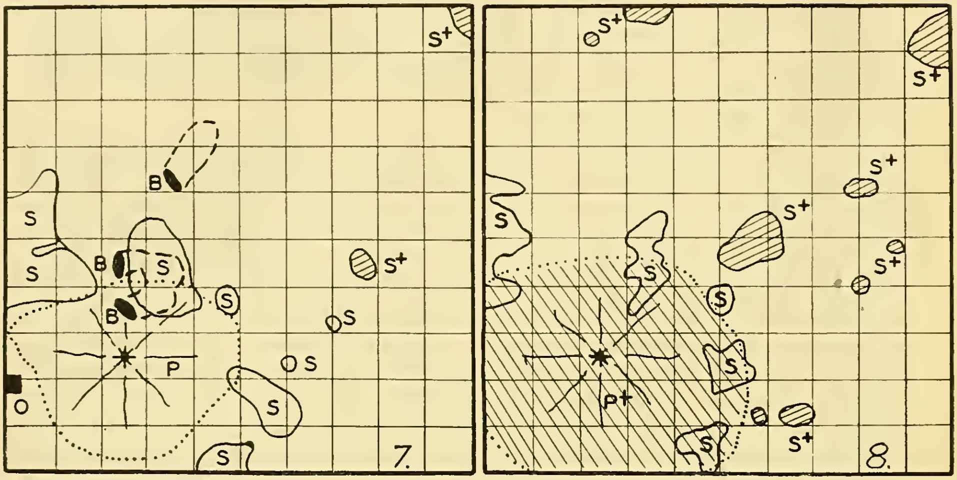

Figs. 7 and 8.—Permanent quadrat in *Stenotaphrum* community between beach and Camp Hummocks, I. Area disturbed by burrowing activities of penguins and mutton-birds. Fig. 7, 18/12/37; Fig. 8, 24/4/38. Side of quadrat 10 ft. (see also Pl. xviii, A and B). Orientation: North side to the left.

(S, *Stenotaphrum secundatum*, living; S^+, do., dead; P, *Phytolacca octandra*, living; P^+, do., dead; O, *Opuntia inermis*; B, burrow. The shading indicates dead plants; *Phytolacca* is represented by an asterisk for the main stem, and a dotted line for the limit of branches. Mouths of burrows represented by black ovals, the limits of the underground portions by broken lines.)

Figures 7 and 8 represent a permanent quadrat in portion of the *Stenotaphrum* community behind the beach, I, where nesting sea-birds have disturbed the soil with their burrows. Figure 7 represents the quadrat on 18.12.37, Figure 8 on 24.4.38. Photographs of the quadrat on these dates are given in Plate xviii, A and B. In these four months, disturbance by burrowing allowed the wind to remove a thickness of two inches from the surface of the sand. This has undermined the *Stenotaphrum*, in parts killing it and thereby further hastening the process of wind erosion. In Plate xviii, B and C, the seasonal change of the *Phytolacca* facies is also visible.

The Sporobolus Community: This community, dominated by *Sporobolus virginicus*, occupies most of the eastern end of II wherever shrubs are not developed, a great proportion of the area of III occupied by vascular plants, and the higher parts of Periwinkle Pt. on I. It occurs in dry soil, or in water-logged soil lying in rock hollows; in sandy soil, or soil derived from igneous rock. The dominant has a high salt-toleration. Properties of soils from four parts of this community are listed in Table 2. In the wetter parts of this community, elements of the *Scirpus cernuus* community (detailed later) sometimes occur; in its drier parts, in addition to *Opuntia*, several small herbaceous species, which may be found by reference to the last column of Table 1, are occasionally present. *Zoisia macrantha* occurs in most parts of this community, and is difficult to distinguish from *Sporobolus* in the absence of inflorescences. Identification on characters of the leaf anatomy has shown that *Sporobolus* is always dominant, as is also indicated by a study of the inflorescences when available. The community is shown in Plates xviii, F, and xix, C.

The Scirpus nodosus Community: This community occupies those areas of I and II from which the sand cover has been removed. The plants grow in small accumulations of sand, 1–2 inches deep, collected round the tussock bases. The properties of soil samples from two localities are given in Table 2. In some places the plants are very widely spaced (Pl. xvii, B and D); but in the neighbourhood of shifting sand which can readily collect round the tussocks, as around High Hummock, a dense stand is formed (Pl. xviii, G). Few other elements enter this community, which occupies a very unfavourable habitat: a few plants of *Inula graveolens, Mesembryanthemum aequilaterale, Enchylaena tomentosa, Salsola Kali,* and very rarely *Phytolacca octandra* on I, and of *Tillaea Sieberiana, Dichondra repens* and *Cyperus polystachyus* on II.

Scirpus nodosus occurs occasionally on small accumulations of soil on rock on I and II, apart from the 'blow-out' areas, and in the *Mesembryanthemum* community on the plateau of IV.

The Mesembryanthemum Community: Small patches of *Mesembryanthemum aequilaterale* occur on all the islands on rock surfaces almost devoid of soil. Forward succession in time, by the colonization of rock surfaces by this species, has not been observed; it may possibly be going on in isolated cases, since equilibrium does not necessarily obtain at present at the lower limit of vegetation. On III this species forms a definite community in shallow soil on the upper part of the island, surrounded by the *Sporobolus* community. The community reaches its greatest development on those parts of the plateau, IV, on which no shrubs occur; in this situation the mat is mingled with other species, and does not form a pure stand as elsewhere.

As recently as March, 1936, the centre of the plateau of IV was clothed with a mixed community, in which *Stephania hernandifolia* was the commonest species, with *Plectranthus parviflorus, Kennedya rubicunda, Dichondra repens, Senecio lautus,* and several other species admixed (Pl. xviii, I). By March, 1938, all of this area was covered by a mat of *Mesembryanthemum aequilaterale,* with other species (*Stephania, Plectranthus,* etc., and *Lepidium hyssopifolium*) occupying a very subsidiary rôle (Pl. xviii, J). We cannot satisfactorily explain this replacement of one community of endemic plants by another of equal or lower integration; however, it was noted in July, 1938, that the mixed community showed some evidence of becoming re-established in a few parts of the centre of the plateau, where the *Mesembryanthemum* mat had been disturbed by burrowing penguins.

Properties of soil samples from two parts of the *Mesembryanthemum* community are given in Table 2, one for the community of the centre of the plateau, IV, the other for shallow soil collected around *Mesembryanthemum* on otherwise bare rock, IV. The latter has a high organic content, suggestive of a stage of a lithosere. In all cases, the situations where this community occurs are well drained.

The Lomandra Community: *Lomandra longifolia* occurs on dune sand, as isolated small hummocks holding the sand at the old level in the 'blow-out' area, on the north side of I (Pl. xvii, B), and, with or without *Stenotaphrum*, on the larger hummocks (Camp Hummocks) in the centre of I (Pl. xvii, A). Properties of soil from the latter situation are given in Table 2 (fourth sample under *Stenotaphrum*). Except for the occasional admixture of *Stenotaphrum* at Camp Hummocks, *Lomandra* forms a pure stand, no other species occurring in this community. On II, *Lomandra* is rare, not forming a definite community.

The Salicornia Community: This community is confined to a hollow on the south side of III, in shallow poorly-drained soil with high salt-content. *Salicornia australis* forms a pure stand, bordered by the *Sporobolus* community on the upper side, where drainage conditions are better (Pl. xix, A). The properties of two soil samples from this community are given in Table 2.

The Spergularia–Claytonia–Portulaca Community: This term has been applied to the vegetation occurring on shallow poorly-drained soils in rock basins on the eastern slopes of IV; similar aggregations occur on the higher parts of V. *Portulaca oleracea* (Pl. xix, B) is the commonest species, but is an annual. Other elements (perennial) are *Claytonia Pickeringi*, *Spergularia rubra*, *Cotula coronopifolia* and *Mesembryanthemum australe.* The species may occur singly or in various combinations. Properties of soil from a typical example of this community are listed in Table 2.

The Scirpus cernuus Community: This term is applied to those aggregates occurring in poorly-drained situations in the lower parts of I and II (Pl. xix, H). *S. cernuus* is often associated with *Samolus repens*, *Apium prostratum* and *Lobelia anceps*, any of which may also occur separately in similar situations. *Samolus* and *Apium* also occur in the moister parts of the *Sporobolus* community.

Soil properties for two parts of this community are listed in Table 2. In some respects, this community corresponds to the *Spergularia–Claytonia–Portulaca* community of IV and V, and the *Salicornia* community of III, but the salt-content appears to be much lower, the highest content being found in soils of the *Salicornia* community. These three communities, however, stand apart from the other communities recognized, in being communities of poorly-drained soils. *Sporobolus* stands in an intermediate position between these three and the remainder in that it tolerates a variety of drainage conditions.

Life-Form Spectra: Table 4 gives life-form spectra (Raunkiaer, 1934) for indigenous and total species for the Five Islands, as a whole and for individual islands. I and II are considered as a single unit. The spectra for Brush Island and for an area of the *Eucalyptus pilularis* association are given for comparison, as well as the 'normal' spectrum. Brush Id. is situated close to the mainland some 75 miles south of the Five Islands, and is composed of augite–olivine–monzonite with a complete dune cover, similar to that which must have been present on I before the 'blow-out' occurred. Its greater area and height, and deeper soil, offer more favourable conditions for plant growth than any on the Five Islands. It possesses 66 species of vascular plants, of which 38 are common to the Five Islands. The *Eucalyptus pilularis* association is given as a typical forest climax on good soil in the same climatic zone as the Five Islands.

It must be remembered that life-form spectra were originally derived for comparing climax vegetations of different climatic zones, although later applied by their originator to local communities other than the climax within one climatic unit. In the present case the spectra are adduced to compare the characteristics of the flora of the islands *inter se* and with other communities, to show correlation with soil formation, shelter, etc. No allowance is made for specific frequency, each species (whether rare or dominant) counting one point; this is the usual procedure, but is not by any means ideal. Again, it is somewhat difficult to apply a terminology based on perennating buds in a climate where most species (except, of course, the therophytes) continue growth at all seasons.

The Five Islands are devoid of phanerophytes other than nanophanerophytes, even these being poorly represented, and more by herbaceous and climbing types than woody shrubs. V, with little soil, and very exposed, has no woody nanophanerophytes. The chamaephyte figure is high in all cases; hemicryptophytes are average, geophytes very rare. Therophytes are well represented, and the effect of the introduced element in raising the therophyte percentage is at once apparent. This is due partly to coincidence; many of the introduced species are Composites, which have wind-borne fruit suitable for the colonization of islands, and, as an entirely independent character, happen to be therophytes. In general, introduced species established on the mainland are largely therophytic, being plants able to avail themselves of rapidly-changing areas of disturbance. The only stem-succulent on the islands is also introduced.

We regard the shrub communities of the Five Islands as a subclimax, not as a local climax under the special climatic conditions of the islands. Brush Island, with almost identical climatic conditions (wind exposure, etc.), develops a low forest of *Banksia integrifolia* Linn. f. and *Casuarina glauca* Sieb. The lack of trees on the Five Islands is therefore attributed to lack of suitable soil conditions rather than to an unfavourable climate; climatically, the shrub communities are a subclimax, the climax not forming because of unfavourable edaphic conditions. In addition to microphanerophytes, Brush Island possesses one epiphytic species (*Platycerium bifurcatum* (Cav.) C. Chr.).

The vegetation of the Five Islands and Brush Island, and especially the facts given by the life-form spectra, may be compared with the data given by Osborn (1922, 1923, 1925) for islands off the coast of South Australia.

Introduced Plants: In Table 5 are given the numbers of introduced species recorded from the Five Islands (individually and collectively) and from Brush Island. In addition, the proportion of introduced to total species is given as a percentage. Both figures must be considered for comparative purposes, the percentage reflecting the effect of the habitable area of each island, and the consequent probability that seeds will reach land, and germinate once they have done so. The low figures for Brush Island are due chiefly to the relatively undisturbed nature of the adjacent mainland, and the rarity of visits by man. Brush Island is in a position relative to the nearest point of the mainland comparable to that occupied by I. The number of introduced species of plants growing on the mainland in the settled areas near Port Kembla is considerable.

The only introduced species at the Five Islands which are not therophytes are *Opuntia inermis* (stem-succulent) and *Stenotaphrum secundatum* (chamaephyte).

Crossing from the mainland to the islands was accomplished in half the species (9 out of 18) by wind-borne fruit, while two species (*Phytolacca octandra, Lycium ferocissimum*) have fleshy fruits. Ground-larks (*Anthus australis*), part of whose diet consists of seeds, are found commonly on I, II and III, and have frequently been observed flying between II and III, and occasionally between I and the mainland. These birds have not up to the present been observed on IV and V, but probably fly there on some occasions.

The observed ability of *Opuntia* to recolonize mainland areas by its cladodes, floating from the islands in the open sea, explains its original invasion of I, II, III and IV, without the necessity of invoking its fleshy fruit as a means of entry; however, officers of the Prickly Pear Destruction Commission have observed crows (*Corvus coronoides*) feeding on *Opuntia* fruits at the islands.

Of the remaining introduced species, *Stenotaphrum* was probably introduced to I. and possibly to II, by man, but its occurrence on IV and V cannot be so explained. On I, its stolons frequently hang down over rocks in long festoons (Pl. xix, J), and the colonization of IV and V is probably due to the carriage of these vegetative parts by sea;[9] carriage of the seeds by birds is less probable. *Atriplex patulum*, which was observed near the beach on I in 1934, but now seems to have died out, was probably introduced by man. *Rumex crispus*, a recent migrant to IV, has a swollen, buoyant anthocarp, which may have floated from the mainland. *Datura Stramonium*, with a large, buoyant capsule, is a recent migrant to I, growing just behind the beach, whither its fruits were probably carried by sea. *Anagallis arvensis* (on I, II, and also on Brush Island) may have been introduced as seed by birds, or may have reached I and II with the introduced mammals. *Malva parviflora*, an introduced species on V, possesses a thin mericarp, which might possibly have floated to the island or have been carried by westerly winds.

Other species which may be indigenous, or may have reached the islands by recent colonization, are *Solanum nigrum*, with a fleshy fruit (on I, II, IV, V, and on Brush Island, where *S. laciniatum* Ait. falls within the same category); *Rumex Brownii* (near the beach, I), with a burr fruit, such as would be carried on human clothing or the hair of introduced mammals; and *Echinochloa crus-galli*, the fruit of which might be eaten by birds, and so carried to V. *Lepidium hyssopifolium*, indigenous in New South Wales, has become increasingly numerous on IV during the last few years, suggesting that it may also be a recent migrant to the islands, possibly as seeds eaten by birds.

Pumpkin, tomato and potato plants, introduced by man, have been observed on I near Camp Hummocks. They have never become properly established, only the first-named showing any evidence of doing so. They have been omitted from Table 1, and from the calculations by which Tables 4 and 5 were derived.

INTERACTION WITH EXTRANEOUS COMMUNITIES.

Interaction with Mainland Communities: Under this heading comes the disturbance of the ecological equilibrium effected by introduced plants. Their means of entry and behaviour on becoming established have already been discussed. The process is probably still continuing. The remaining interactions may be listed as follows: (A) Introduced animals which have become established on the islands, and now form an integral part of the island life; (B) Animals coming to the islands as temporary but regular visitors, and definitely entering the island food-chains; (C) Animals reaching the islands by chance, of irregular and transient occurrence. (B) and (C) are concerned chiefly with species indigenous in this region.

(A).—1. The introduced fly *Lucilia sericata* Meig. is common on I; the journey from the mainland is well within its normal flight range.

2. The introduced scale-insects *Saissetia oleae* Bern. and *Ceroplastes destructor* Newst. are established on the islands, the former on I and II, the latter on IV. This invasion is possibly to be attributed to the minute first-instar larvae being carried by strong westerly winds.

3. As noted earlier, goats and rabbits were introduced by man many years ago. The latter are established as a definite part of the biome; the former became extinct only by interference from without.

4. The moth *Cactoblastis cactorum* Berg. has been introduced to I by officers of the Prickly Pear Destruction Commission. It has become well established, and has spread to IV, apparently by its own powers of flight.

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[9] Stolons of this type, lacking roots, were immersed in sea-water for 18 hours, exposed without soil or water for 14 days, and then placed in moist sand. Within a further 14 days adventitious roots and new leaves were formed.

(B).—1. Human beings disturb the balance of the biome by killing members of the animal population, and add to the islands additional habitats in excreta and discarded food. The human factor pre-dates the advent of Europeans, as is indicated by an aboriginal midden, with discarded flints and large shells, on I (Pl. xvii, D). This may pre-date severance of the island from the mainland, but not necessarily so, as in Cook's journal there is a reference to canoes used by natives in this locality.

2. Ground-larks are probably the only land-birds nesting on the islands. Birds of prey, such as the Nankeen Kestrel (*Cerchneis cenchroides*), derive much of their food supply from the islands, but are not continuous residents. The Boobook Owl (*Spiloglaux novae-seelandiae*) has been observed on I and II, where it rests by day in holes in steep rock-faces, and hunts at night, flying also to IV. It is reasonably certain that it does not nest at the islands. Swallows (*Hirundo neoxena*) are frequently seen hawking over I and II, but have not been observed to breed there; they have been seen flying between I and the mainland. Quail (*Ypsilophorus ypsilophorus*) occur rarely on II, probably seasonally, as on Brush Island. The Black-and-White Fantail (*Leucocirca volitans*) and Silver-Eye (*Zosterops lateralis*) occur, the former having been observed frequently on I, II and III, the latter rarely on I. These birds may possibly breed at the islands, but this has not been observed. In all the above instances, and in the case of the ground-larks breeding at the islands, interaction occurs between the islands themselves, in addition to interaction with the mainland.

3. Odonata (Anisoptera and Zygoptera) have been observed on III, where no breeding habitat exists; these individuals probably developed in Triangle Pool, II. Anisoptera have been observed on IV, where there does not appear to be any breeding habitat; these individuals were probably from the mainland. In fact, it is possible that all the islands are visited by Odonata from the mainland.

4. Although there are no nests on the islands, bees (*Apis mellifera* L.) have been observed on several occasions on IV, gathering nectar from flowers (particularly of *Plectranthus parviflorus*) on the plateau. This is probably a regular occurrence. This example is included here, rather than under (A), although *Apis* is introduced.

(C).—The butterfly *Tisiphone abeona* Don. has been observed on IV, although its food-plant (*Gahnia*) does not occur on the Five Islands. Cicadas (e.g., *Thopha saccata* Fabr.) have also been observed to fly from Red Pt. to I, and have been observed on III following westerly winds. These and other winged insects are irregular visitors to the islands, possibly entering the food-chains, although not in the regular manner comparable with the instances under (B).

Interaction with Marine Communities:

(A).—The following marine birds breed at the Five Islands: The Little Penguin (*Eudyptula minor*), very common on I and II, occasional on III, and IV and V; the Wedge-Tailed Shearwater or Mutton-Bird (*Thyellodroma pacifica*), very common on I, occasional on II and III; the Silver Gull (*Bruchigavia novae-hollandiae*), common on III and probably on V; the White-Faced Storm Petrel (*Pelagodroma marina*), fairly common on II; the Black Oyster-Catcher (*Haematopus ostralegus*), rare on IV; and the Red-Capped Dotterel (*Leucopolius ruficapillus*), rare on I. The last species nests in the more open parts of the *Scirpus nodosus* community on the 'blow-out' area of I, where it may possibly derive some of its food from terrestrial sources. The Crested Tern (*Thalasseus bergii*) is common near the islands, in some years nesting on III, and possibly on V (although we have not been able to land on this island during the breeding season).

The effect of these birds in raising the combined nitrogen in the soil is shown in Table 3. Little effect of the increased nitrogen content on the vegetation can be noticed; *Stenotaphrum* is somewhat more robust than in most mainland situations, but the burrowing activities of *Eudyptula* and *Thyellodroma* more than counteract any benefit the vegetation might receive from the sea-birds. On Brush Island, the creeper *Kennedya rubicunda* develops leaves several times the size of those of plants from other localities. This may be a result of the manuring of the soil by birds. The excreta of birds also raise the phosphate and nitrate content of pool waters, favouring protophyta, the base of some pool food-chains.

The sea-birds, especially those forming burrows, provide a habitat for nest-parasites (Siphonaptera, etc.), whilst lizards (*Lygosoma* spp.) frequently use empty nests as retreats. The ticks *Ornithodorus* and *Ixodes* are true ectoparasites when the birds are present on the islands, at other times resting on and under rocks (IV, V); at this stage they are occasionally eaten by lizards. The sea-birds also appear to form part of the diet of birds of prey; on Brush Island we observed several crows (*Corvus coronoides*) feeding on a freshly-killed Little Penguin, and on Lady Julia Percy Island the Swamp Harrier (*Circus juxta*) is recorded as feeding on mutton-birds during the breeding season (McCoy Society Report, l.c., p. 429). Both *Corvus coronoides* and *Circus juxta* occur frequently on the Five Islands (I–III), but we have not observed this feeding-habit there. However, many sea-birds have been seen dead on the higher parts of I, II and III, probably from this cause. Dead sea-birds also enter terrestrial food-chains as the habitat of carrion insects (Muscoid flies, Histeridae, Staphylinidae, Dermestidae, etc.).

(B).—Two species, the Marine Caddis-Fly (*Philanisus plebejus* Walk.) and the Marine Tipulid (*Limonia* (*Dicranomyia*) *marina* Sk.) occur on the Five Islands, the larvae feeding on algae in the littoral zone, the adults being terrestrial. Adults of *Philanisus* have been taken as far from the shore as Camp Hummocks, in the centre of I. Both species almost certainly enter terrestrial food-chains.

(C).—Insects, particularly Muscoid flies, both larvae and adults, are found on carrion of marine origin about the high-tide mark, especially on the beach, I. Muscoid larvae have been recorded living in dead pieces of the Ascidian *Cynthia* on the beach, I, well below the high-tide mark. The adults of these species certainly enter terrestrial food-chains; lizards (*Lygosoma* (*Hinulia*) *quoyi* Dum. et Bibr.) frequent the zone behind the beach, I, feeding on adult flies, and the Black-and-White Fantail has been observed feeding on flies between tide-marks on the beach.

(D).—Insects, particularly Coleoptera such as Staphylinidae, and Diptera (Phycodromiidae, Anthomyiidae, etc.), have their habitat in aggregations of dead kelp (*Ecklonia*) washed up at the extreme limit of waves, especially on the isthmus between I and II and on the northern rock-platform of IV. These insects form a separate community, which is linked with typically terrestrial communities by spiders which at times frequent it. The habitat of Machilids (*Allomachilis froggatti* Silv.) on IV contains vegetable detritus of terrestrial and marine origin (dead leaves of *Kennedya*, etc.; dead coralline sea-weed, etc.), and either or both may form the food of the Machilids.

(E).—The common littoral crab *Leptograpsus variegatus* (Fabr.) is frequently found in pools above the reach of waves, including those of low salinity (e.g., Triangle Pool). Specimens of this crab have been collected in pools 45 feet above mean tide level on III, with insect remains (larvae and pupae of *Aedes* (*Pseudoskusca*) *concolor* Tayl., and larval Chironomidae) in the crop.

(F).—The periwinkle *Nodilittorina tuberculata* (Menke) occurs on rocks 40 feet and more above mean tide level, both on dry rock-faces and in pools, particularly on Periwinkle Pt., I. *Melarhaphe unifasciata* (Gray) occurs at slightly lower elevations. Marked specimens of *Nodilittorina* remained at about 40 feet above mean tide level on I from August, 1937, to July, 1938, only a small percentage showing any tendency to migrate seawards. This species was observed copulating on rocks 25 feet above mean tide level on IV (March, 1938). It probably derives its food from the zone where it occurs most frequently. The rocks there are covered with placoid lichens, and the periwinkles may possibly feed on these, or on detritus in rock pools. Periwinkles do not appear to act as food (as carrion or otherwise) to any extent for terrestrial animals, so that, even if they derive food from terrestrial sources, the food-chain is a 'blind' one.

ANIMAL HABITATS.

From the point of view of animal ecology, each plant community, or for phytophagous species each plant species, may be taken as the habitat unit, and this can be further subdivided. Thus *Correa alba* offers at least five different habitats: (1) The leaves, accommodating leaf-eating beetles, leaf-miners, etc.; (2) the flowers, the habitat for thrips, etc., as well as for nectar-feeders paying occasional visits; (3) the stems, the habitat of Coccidae; (4) the accumulation of dead leaves (A_0 horizon) on the soil surface, the habitat of Blattidae, Embioptera, etc.; and (5) the underlying soil, where earth-worms, etc., may occur. Carnivorous species, however, especially birds and winged insects, cannot be assigned to any such community, but are wides ranging through many plant communities, and elsewhere.

It would be superfluous to enumerate all the situations, comprised in the communities of vascular plants, which form habitats for animal communities on the islands; below are enumerated those habitats of terrestrial animals (as opposed to marine) which are not included in vascular plant communities.

(1) *Pool habitats*:

(*a*) *Triangle Pool* (Pl. xix, D): This is the largest pool (other than strictly littoral pools) on the islands; it is some 10 yards long, of varying width, and up to about three feet deep. Its position is marked on Figure 2 (G). The elevation above mean tide level (29 ft.), and the overflow system, maintain the pool at a low salinity, ranging in our experience from 3·5 to 6·0‰ (sea-water 35‰). A dense population of protophyta maintains a high oxygen-content at most times. The phosphate and nitrate supply is good, on account of the presence of sea-birds nesting above the pool. At a time when protophyte production was extremely high (the water being a vivid green), the phosphate content was 90 mgm./cu.m., the nitrate low (c. 10 mgm./cu.m.); these figures are not representative, as much of the soluble nitrate and phosphate was obviously contained in the organic life present. The protophyta are chiefly Desmids, *Scenedesmus* being very abundant.

Triangle Pool supports a varied animal population, notably the larvae of Odonata, Chironomidae, and the mosquito *Aedes concolor*; adults and larvae of Corixids, Notonectids, Dytiscids and Gyrinids; and a surface population of water-skaters (Gerridae).

(*b*) *Freshwater Springs* (Pl. xix, E): These two pools are situated about 28 feet above mean tide level, behind and to the south of the beach, I (Fig. 2, B). They are man-made ponds dug in the *Stenotaphrum* community to a depth of about five feet, the water being retained by a clayey soil, probably the 'Y' horizon referred to earlier. Their salinity is low (within our experience, usually 0·45–0·70‰, rarely as high as 1·08‰), due both to the shelter of this area from spray, and to continual drainage. The animal population appears to be restricted to larvae of Chironomidae and of *Aedes concolor*.

(*c*) *Phragmites Soak*: Water seeping through a sand-drift on the south side of I, and flowing at all times except in very dry seasons, accumulates in hollows in the dolerite about 25 feet above mean tide level. Almost continual flow keeps the salinity low (normally about 0·50‰ for the highest pool, and 0·95‰ for a pool some 5 feet lower down (Pl. xix, H)), in spite of low elevation. The upper pool (Pl. xix, G) occasionally dries up, passing through stages of high salinity. The population of these pools consists chiefly of larvae of *Aedes concolor*, with Corixids, Notonectids, and a few Amphipods.

(*d*) *Pools of High Salinity*: Many rock-pools above the reach of the tide, but filled frequently with spray and with a salinity approximating to that of sea water, form the habitat of larvae of *Aedes concolor*, but appear to be too saline for other insects. A pool on Periwinkle Pt., I (Pl. xix, F), although 40 feet above mean tide level, falls in this category, its salinity ranging from 18·9 to 50·8‰ in our experience; it seldom overflows, on account of the contour of the rock, and in effect acts as a concentrating-pan for the large amounts of spray which are driven across Periwinkle Pt. by southerly winds. In addition to the larvae of *Aedes concolor*, periwinkles (*Nodilittorina tuberculata*) inhabit this pool.

Pools of this fourth type are common about the 10–20 ft. contours on I and II, and on III occur up to about 45 feet. Some of the pools on the upper parts of III have a fairly low salinity (down to 4·25‰ on some occasions), and Corixids and Chironomid larvae occasionally occur in them; but the other types which are found in Triangle Pool, with a comparable salinity, are not present in the pools of III. On the platform and eastern slopes of IV, pools of the fourth category occur, some with salinity low enough to accommodate Corixids and Notonectids. On the higher parts of V, small rock-pools occur, with larvae of *Aedes concolor*, and species of Cladocera and Ostracoda. The only sample which we have been able to secure from V for salinity determination, from a pool on the top of the island, gave a value of 14·2‰, at a dry period when pools on the other islands were showing unusually high salinities.

(2) *Rock habitats*:

(*a*) *Lichens on rock surfaces*: In nearly all places above the 10-ft. contour where igneous rock is exposed, placoid lichens develop in abundance. The frequent occurrence of *Nodilittorina tuberculata* in this situation suggests that it may feed on lichens. The moth *Halone sinuata* Walk. occurs in this zone, its larvae apparently feeding on lichens.

(*b*) *Boulders*: Accumulations of rounded boulders immediately below the lower limit of vascular plants afford an animal habitat on the south-western part of I and the eastern slopes of IV. In the latter place, Machilids are particularly abundant, and lizards, spiders and ants sometimes occur. Few species occupy this habitat on I. Boulders in the more open parts of the *Scirpus nodosus* community in the 'blow-out' area of I offer shelter to large numbers of Dermaptera, and occasionally to other types.

(*c*) *Mosses and Liverworts*: On I, mosses and the liverwort *Marchantia* occur in moist situations on rocks or soil, and on the eastern slopes of IV mosses grow under similar conditions. The area of this habitat is very restricted, and it is doubtful whether it is occupied by any characteristic animal types.

(3) *Kelp*: This community, which has been mentioned earlier, scarcely constitutes a typically terrestrial habitat, falling rather in the littoral zone.

(4) *Bare sand*: Drifts of bare sand occur on the slopes on the north and south-east of I, and similar situations occur within vascular plant communities, as in the disturbed parts of the *Stenotaphrum* community. Bembecid wasps are the main frequenters of this barren habitat, and they derive their food from other areas.

VARIETY OF ANIMAL TYPES.

A diverse animal population is present on the Five Islands, including mammals (introduced rabbits), land birds (about a dozen species), reptiles (at least four species of lizards), land Mollusca (one species), insects (16 orders, with more than 50 families represented), numerous species of Arachnids, Myriapods (Chilopoda, Diplopoda), Crustacea (terrestrial Isopods and Amphipods; Cladocera and Ostracoda in pool habitats), and one terrestrial species of Oligochaeta. The animal populations will be dealt with specifically in subsequent papers.

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(In addition to works quoted in the text, the above list includes the sources of most of the taxonomic names used in the paper. The names used for birds are in all cases those given by Mathews, and authors of species have therefore been omitted.)

TABLE I.

Explanation: For Life-Form symbols, see explanation to Table 4.
Introduced species marked with an asterisk.
Abbreviations: vr, very rare; r, rare; o, occasional; c, common; c1, common (locally dominant), c2, common (locally co-dominant); lc, locally common; o1, occasional (locally common); o2, occasional (locally co-dominant).

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
Dilleniaceae.							
Hibbertia volubilis Andr.	r	—	—	—	—	N′.	Among *Stenotaphrum* on north-west portion of **I**.
Menispermaceae.							
Stephania hernandifolia (W. et Arn.) Walp.	—	—	—	c	—	Ch.	Epharmonic variation with relatively small leaves, growing as a low straggling creeper on plateau, **IV**; formerly the commonest plant on central part of plateau, now partly displaced by *Mesembryanthemum aequilaterale*.
Cruciferae.							
Lepidium hyssopifolium Desv.	—	—	—	c	—	Th.	Moderately common on plateau, **IV**; has increased since 1936, when it was very rare.
Rutaceae.							
Correa alba Andr... ..	r	c1	o2	c2	—	N.	Dominant or co-dominant in nearly all areas carrying shrubs.
Oxalidaceae.							
Oxalis corniculata Linn. ..	r	r	—	r	—	H.	On bare sandy soil, or in grassland (**I**, **II**); in centre of plateau (**IV**).
Malvaceae.							
Malva parviflora Linn.*	—	—	—	—	vr	Th.	In shallow soil on higher parts of island.
Portulacaceae.							
Claytonia Pickeringi (A. Gray) F. v. M.	—	—	—	c	—	Ch.	In shallow moist saline soil in rock basins, eastern slopes of **IV**.
Portulaca oleracea Linn.	—	—	o	c	c	Th.	Similar situations to the preceding species, on **III**, **IV** and **V**.
Caryophyllaceae.							
Spergularia rubra (Linn.) J. et C. Presl.	—	—	vr	o	r	Ch.	As for *Portulaca*.
Chenopodiaceae.							
Atriplex cinereum Poir. ..	—	—	—	r	o	N′.	On **IV**, rare on slopes and plateau; on **V**, in shallow soil in rock crevices, etc.; appears to be increasing in numbers on **V** (July, 1938).
A. patulum Linn.* ..	vr	—	—	—	—	Th.	In *Stenotaphrum* community near beach, **I**; only seen on earlier visits (1934–5).
Enchylaena tomentosa R.Br.	r	r	o	c	—	Ch.	Usually on dry sandy soil, or in rock crevices with little soil.
Rhagodia baccata (Labill.) Moq.	—	vr	—	—	—	Ch.	In *Stenotaphrum* community.
R. hastata R.Br. ..	o	o	c	o	vr	Ch.	In *Stenotaphrum* community on **I** and **II**; in *Sporobolus* community on higher parts of **III**; on **IV**, both on plateau and eastern slopes.
R. nutans R.Br.	—	—	—	r	—	Ch.	In rocky situations.
Salicornia australis Banks et Sol.	—	—	c1	—	—	Ch.	In wet saline soil in cuppings of the underlying rock.
Salsola Kali Linn. ..	r	—	—	—	—	Th.	In dry sandy situations.
Aizoaceae.							
Mesembryanthemum oequilaterale Haw.	o	o	c	c	o	Ch.	Locally common on rocks, with little soil; also on those parts of the plateau, **IV**, lacking shrubs, where it has become dominant since March, 1936.

TABLE 1.—*Continued.*

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
M. australe Sol.	—	—	—	vr	—	Ch.	As for *Claytonia*.
Tetragonia expansa Murr.	lc	lc	o	o	o	Ch.	On **I** and **II** forms a distinct local facies of the *Stenotaphrum* community; elsewhere in shallow soil on rocks, or rarely on plateau of **IV**. Listed as an annual by Moore and Betche, but perennial in these localities according to our observations.
Polygonaceae.							
Rumex Brownii Campd. ..	vr	—	—	—	—	N′.	A few plants behind the beach in the *Stenotaphrum* community, **I**; observed only on recent visits (since August, 1937); possibly a recent migrant to the island, though indigenous in this part of New South Wales.
R. crispus Linn.*	—	—	—	vr	—	Th.	On eastern slopes, **IV**; first observed in March, 1938, and probably a recent migrant. Apparently therophytic in this locality.
Phytolaccaceae.							
Phytolacca octandra Linn.*	c	o	—	vr	—	Th.	Usually on sandy soil; forms a distinct local (seasonal) facies of the *Stenotaphrum* community on **I**.
Leguminosae.							
Desmodium varians (Labill.) Endl.	—	—	—	vr	—	Ch.	Eastern slopes of **IV**.
Glycine clandestina Wendl.	—	—	—	r	—	Ch.	On plateau, **IV**.
Kennedya rubicunda Vent.	r	o	vr	o	—	N′.	Climbing over other plants, e.g. *Stenotaphrum* on **I** and **II**, and *Westringia* on plateau of **IV**. Classed as a nanophanerophyte, but more of a chamaephyte on **I** and **II** on considerations of height.
Crassulaceae.							
Tillaea Sieberiana Schultes	r	r	—	o	—	Ch.	In dry rocky situations.
Umbelliferae.							
Apium prostratum Labill.	o	o	o	—	—	Ch.	In moist soil amongst rocks, usually at a low elevation.
Cactaceae.							
Opuntia inermis P.DC.*	c	c	c	c	—	S.	On dry soil or almost bare rocks, often becoming dominant, or co-dominant with *Stenotaphrum*, etc., but subjected from time to time to attempts at eradication.
Compositae.							
Centipeda minima (Linn.) A.Br. et Aschers	—	—	—	o	—	Th.	On plateau, **IV**.
Cirsium lanceolatum (Linn.) Scop.*	r	r	—	—	—	Th.	In more open parts of *Stenotaphrum* community.
Cotula australis (Less.) Hook f.	—	o	—	vr	—	Th.	In *Sporobolus* community, **II**; on eastern slopes, **IV**.
C. coronopifolia Linn. ..	—	—	—	o	—	Ch.	As for *Claytonia*.
Erechthites arguta (A. Rich.) DC.	—	—	—	o	—	Th.	On plateau, **IV**.
Gnaphalium luteo-album Linn.	r	r	—	—	—	Th.	In *Stenotaphrum* and *Sporobolus* communities.
Hypochoeris glabra Linn.*	—	—	—	r	—	Th.	On plateau. Only seen on recent visits (March, 1938), probably a recent migrant.
Inula graveolens (Linn.) Desf.*	o	—	—	—	—	Th.	On bare soil, as in the more open parts of the *Scirpus nodosus* community; very rare on our earlier visits, has increased markedly in numbers (1938).
Onopordon Acanthium Linn.*	r	r	—	—	—	Th.	In more open parts of *Stenotaphrum* community.

TABLE 1.—*Continued.*

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
Senecio lautus Sol.	r	r	c	o	—	Ch.	In *Stenotaphrum* community on **I** and **II**; in *Sporobolus* community on **III**; on plateau. **IV**.
S. mikanioides Otto.*	o	ol	—	o	—	Th.	On **I** and **II**, scrambling over *Stenotaphrum* and dead remains of *Opuntia*; on plateau. **IV**.
Sonchus asper Hill*	r	r	—	—	—	Th.	On bare soil.
S. maritimus Linn.*	r	r	—	r	—	Th.	As *S. asper*.
S. oleraceus Linn.*	r	r	r	o	r	Th.	As *S. asper*, sometimes on almost bare rocks; also in more open parts of *Stenotaphrum* community on **I** and **II**.
Taraxacum officinale Weber*	—	—	vr	r	—	Th.	As *Sonchus asper*.
Campanulaceae.							
Lobelia anceps Thunb.	o	o	—	c	—	Ch.	In same situations as *Apium*, occasionally in drier situations.
Wahlenbergia gracilis (Forst. f.) A.DC.	vr	vr	—	—	—	Th.	In grassland.
Goodeniaceae.							
Scaevola calendulacea (Andr.) Druce.	vr	—	—	—	—	Ch.	In *Stenotaphrum* community, north-west portion of **I**.
Gentianaceae.							
Erythraea australis R.Br.	r	r	—	—	—	Th.	In grassland.
Plantaginaceae.							
Plantago varia R.Br.	r	—	—	c	—	Ch.	Usually in shallow soil in rock crevices.
Primulaceae.							
Anagallis arvensis Linn.*	r	r	—	—	—	Th.	In more open parts of *Stenotaphrum* community.
Samolus repens (Forst.) Pers.	o	o	vr	r	—	Ch.	In similar situations to *Apium*.
Asclepiadaceae.							
Marsdenia rostrata R.Br.	r	—	—	—	—	N′.	Scrambling over *Stenotaphrum*, north-west corner of **I**.
Convolvulaceae.							
Dichondra repens Forst. et f.	r	r	o	c	—	H.	On **I**, **II** and **III**, in dry sandy soil or more open parts of grass communities; on **IV**, on plateau and ledges of westerly rock face.
Solanaceae.							
Datura Stramonium Linn.*	vr	—	—	—	—	Th.	A few plants near the beach, **I**. First observed in 1938, and probably a very recent migrant.
Lycium ferocissimum Miers*	—	—	—	—	vr	Th.	In shallow soil between rocks; apparently therophytic in this locality.
Solanum nigrum Linn.	vr	vr	—	vr	vr	Th.	In grassland (**I**, **II**); on plateau (**IV**); in shallow soil on top of **V**. Doubtfully native.
Labiatae.							
Plectranthus parviflorus Henck.	r	r	—	c	—	N′.	Usually in dry shallow soil in rock crevices; also in *Stenotaphrum* community (**I**, **II**), and on plateau (**IV**). Barely falls within the nanophanerophyte class.
Westringia rosmariniformis Sm.	r	o2	—	c2	—	N.	Co-dominant with *Correa* in shrub communities of **IV** and parts of **II**; on **IV** attains local dominance in some places. A few bushes on the north side of **I**.
Myoporaceae.							
Myoporum ellipticum R.Br.	—	—	o2	c	—	N.	Forms a local facies of the shrub community on **IV**; co-dominant on **III** where shrubs are developed.
Liliaceae.							
Lomandra longifolia Labill.	c	vr	—	—	—	H.	As tussocks holding the sandy soil at the former level on **I**; on **II**, rare in the *Stenotaphrum* community.

TABLE 1.—*Continued.*

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
Commelinaceae.							
Commelina cyanea R.Br.	c	o	r	c	c	Ch.	On **I**, **II** and **III**, in grass communities; on **IV**, on plateau and ledges of westerly rock face; in shallow soil in rock crevices on **V**.
Centrolepidaceae.							
Centrolepis fascicularis Labill.	—	o	—	—	—	Th.	In *Sporobolus* community, locally fairly common.
Cyperaceae.							
Cyperus (*Pycreus*) *polystachyus* (Rottb.)	o	o	—	—	—	H.	In dry shallow soil.
Scirpus cernuus Vahl. ..	o	o	—	vr	—	Ch.	In similar situations to *Lobelia*, *Samolus* and *Apium*.
S. nodosus Rottb... ..	cl	o	r	o	—	H.	In shallow accumulations of sand, or on almost bare rock; also in central part of plateau, **IV**.
Gramineae.							
Agrostis avenacea Gmel. (=*Calamagrostis filiformis* (Forst.) Pilger).	r	—	r	o	—	Th.	Among *Stenotaphrum* or *Sporobolus* (**I**, **III**); in shallow soil amongst rocks, eastern slopes of **IV**.
Calamagrostis quadriseta (Labill.) Spreng.	vr	r	—	—	—	H.	In *Stenotaphrum* community.
Cynodon dactylon Rich. ..	r	r	—	—	—	H.	In *Stenotaphrum* community.
Digitaria marginata Link.	vr	—	—	c	c	Th.	In *Stenotaphrum* community (**I**); in shallow soil amongst rocks (**IV**, **V**).
Eleusine indica Gaertn. ..	—	—	—	—	vr	Ch.	In shallow soil on higher parts of island.
Echinochloa crus-galli (Linn.) Beauv.	—	—	—	—	vr	Th.	In similar situations to the preceding species. Possibly introduced, but allowed as indigenous by Moore and Betche.
Entolasia marginata (R.Br.) Hughes.	—	—	—	r	—	H.	On ledges of western rock face, **IV**.
Imperata cylindrica (Linn.) Beauv. var. *Koenigii* D. and S.	o	r	—	—	—	H.	In *Stenotaphrum* community.
Paspalum distichum Linn.	—	—	—	vr	r	H.	In shallow soil in rock crevices.
Phragmites communis Trin.	lc	—	—	—	—	H.	In *Stenotaphrum* community at low elevations, south side of **I**.
Setaria glauca (Linn.) Beauv.	o	vr	—	—	—	Th.	In *Stenotaphrum* and *Sporobolus* communities.
Sporobolus virginicus (Linn.) Kunth.	o	cl	cl	—	—	H.	Dominant over most of the western part of **III**, and on the eastern part of **II** wherever shrubs are not developed. On **I**, dominant only on Periwinkle Pt., apparently having been displaced elsewhere on **I**, and on the western end of **II**, by *Stenotaphrum*. On dry sandy soil, and on ill-drained soil amongst rocks.
Stenotaphrum secundatum (Walt.) Kuntze*	cl	cl	—	o	o	Ch.	Dominant over much of **I** and **II**, on sand. On **V**, in soil in rock crevices. Since 1934, has colonized **IV**, being now well established on eastern slopes and plateau. Grows as a chamaephyte in these localities, though hemicryptophytic in some localities.
Themeda australis (R.Br.) Stapf.	—	o	—	—	—	H.	In dry shallow soil on rocks, and in *Stenotaphrum* and *Sporobolus* communities.
Zoisia macrantha Desv. ..	r	o	r	—	—	H.	With *Sporobolus*.
Polypodiaceae.							
Pteridium aquilinum (Linn.) Kuhn.	o	o	—	—	—	G.	In *Stenotaphrum* community.

TABLE 2.

Properties of surface soils (0–2 inches) from various communities.

Community and Location.	Height above Mean Tide Level.	pH.	Loss on ignition (%).	W.R.C. (%).	Chloride (%).
	Feet.				
Correa-Westringia community :					
Correa, Centre of **II** : Soil 1 ft. deep, derived from dune sand contaminated with doleritic soil. Well drained*	45	6·0–6·1	11·2	58	0·026
Correa-Westringia, Centre of **II**, south side. Depth, origin and drainage as last	35	5·9–6·0	16·5–17·9	63	0·101–0·112
Correa-Westringia, **IV**, plateau, north end: Soil 1 ft. deep, well drained, derived from trachy-andesite	40	5·2–5·3	45·0–50·2	125	0·034
Stenotaphrum community :					
High Hummock, **I** : Dune sand, 8 ft. deep, very well drained	70	5·3–5·4	1·6–4·5	28–37	0·013
II, west end : Soil 2 ft. 6 in. deep, derived from dune sand, well drained	40	5·3–5·4	10·8	43	0·052
I, between beach and Camp Hummocks : Deep dune sand, well drained. (*Tetragonia* on sample with 11% humus)	25	5·9	8·0–11·0	38–54	0·023
I, Camp Hummocks : Deep dune sand. well drained. With *Lomandra longifolia*	50	5·8	1·2	28	0·014–0·015
Sporobolus community :					
I, Periwinkle Pt. : Soil 8–15 inches deep, derived chiefly from dune sand, with slight contamination from dolerite ; not very well drained	40	6·1–6·2	13·3	51–56	0·032
II, centre, south side : Soil 1 ft. deep, fairly well drained, derived from dune sand contaminated with doleritic soil	35	6·6–6·7	12·5	70	0·064
II, south-east corner : Soil 1 ft. deep, derived chiefly from underlying dolerite ; poorly drained because of cupping of underlying rock*	35	6·5	15·0	104	0·056
III, top of island, west end : Soil about 1 ft. deep, well drained, derived from dolerite, possibly with slight admixture of wind-borne sand	50	5·5	25·6	86–102	0·093
III, near ecotone with *Salicornia* community : Soil 6 in. deep, derived from dolerite, poorly drained	35	7·2–7·4	18·1–21·1	112	0·443–0·653
Scirpus nodosus community :					
I, 'blow-out' area : Recent sandstone, with 1–2 inches of wind-blown sand collected around *Scirpus* tussocks ; very dry and well drained	50	5·4	3·0	29	0·036
II, 'blow-out' area, near east end : Soil similar to last, but resting on dolerite, not sandstone	45	6·2	3·4	33	0·032–0·033
Mesembryanthemum community :					
IV, Centre of plateau : Soil 2 ft. deep, well drained, podsolized, derived from trachy-andesite	40	5·4–5·5	26·5	101	0·092
IV, edge of plateau : Soil 1–2 inches deep, restricted to vicinity of plant, rock elsewhere bare ; soil well drained, derived from trachy-andesite	35	6·0–6·1	44·9	162	0·203

* Water content (20/8/37) 14% and 84%, respectively, of the dry weight.

TABLE 2.

Properties of surface soils (0–2 inches) from various communities.

Community and Location.	Height above Mean Tide Level.	pH.	Loss on ignition (%).	W.R.C. (%).	Chloride (%).
	Feet.				
Salicornia community:					
III: Soil 3 inches deep, derived from dolerite, very badly drained	30	7·4–7·5	11·4	97	0·848
III: Soil 6 inches deep, as above, but with slightly better drainage; near ecotone with *Sporobolus* community	35	6·9–7·0	30·4	148	0·460
Spergularia-Claytonia-Portulaca community:					
IV, eastern slopes: Soil 1–3 inches deep, derived from trachy-andesite; poorly drained, in rock basin	25	5·7–5·8	29·4–32·3	116	0·117
Scirpus cernuus community:					
I, below High Hummock: Dune sand 3 inches deep, lodged in rock crevices; poorly drained	25	6·8	8·2	48	0·062
I, below *Phragmites* Soak: Soil 1 inch deep, dune sand accumulated in shallow rock-pool, filled from slowly-running soak; salinity of pool when soil collected, Cl 0·76‰	20	6·6–6·7	3·5	33	0·029
Lomandra community:					
See Sample 4 of *Stenotaphrum community.*					

The pH values were measured by the quinhydrone method (gold electrode) as soon as practicable after collection of the sample, usually within three days. Little drift was observed in the pH when the soils were stood with water for varying times, very probably because of natural buffering.

For the other estimations all soils were previously passed through a 1 mm. sieve. The percentage loss on ignition of oven-dry soil gives a fairly reliable measure of the organic matter (humified and unhumified), little clay and practically no calcium carbonate being present. Water-retaining capacity was calculated by weighing saturated soils, contained in squat metal cylinders with gauze bottoms lined with filter-paper, and weighing again after drying in an oven at 90°–100° C. The W.R.C. is expressed as a percentage of the dry soil, allowance being made for the water held by the apparatus at the first weighing. The figures are comparable *inter se*, but higher than would be obtained by most methods. The chloride content (expressed as percentage Cl-ion per unit dry weight of soil) was obtained by lixiviating known weights of oven-dry soil with hot distilled water, and estimating the filtrate with standard silver nitrate. The salinity of the soil solution, involving water-content of the soil, was judged too variable from season to season to merit calculation.

The pH values are controlled by (1) the origin of the soil, dune sand being lowest, soil derived from trachy-andesite intermediate, that derived from dolerite highest; (2) salinity, as given by chloride content, high salinity raising the pH; and (3) humus-content, high humus-content lowering the pH. The humus-content is largely controlled by drainage, poorly-drained soils having high humus-content; soils from shrub communities are also rich in organic matter generally on account of accumulations of dead leaves. *Mesembryanthemum* as a stage in a lithosere also has a soil of high organic content. The W.R.C. is controlled by texture (low for dune sand, high for soils from igneous rocks), and by organic content. The chloride content is governed both by incidence of salt spray (depending on aspect, height and distance from shore), and by leaching, poorly-drained soils tending to have a high salinity.

TABLE 3.

Soil Sample.	Nitrate (mgm. N_2O_5 per gm.).	Phosphate (P_2O_5, parts per million).	NH_3.
Stenotaphrum community, penguin rookery between beach and Camp Hummocks, I ..	0·086	3·03–4·72	+
Stenotaphrum community, High Hummock, I: No birds nesting near this situation ..	0·004	5·76	—
Dune community, mainland at Red Point: No birds present	0·010	3·54	—

Phosphate, nitrate and ammonia content for soil from a penguin rookery, and from similar plant communities where no birds are normally present. Nitrate and phosphate estimated colorimetrically, the former in filtrates from known weights of dry soil within 24 hours of collecting, the latter from known weights of dry soil, calcined and lixiviated. Ammonia was estimated qualitatively with Nessler's Reagent, in filtrates from aliquot parts of soil; + represents a deep colour, — no colour.

TABLE 4.

Life-Form Spectra.

	S.	E.	MM.	M.	N.	N'.	Ch.	H.	G.	HH.	Th.	Number of Species.
Five Islands, I-V—												
(A)	—	—	—	—	5	10	38	22	2	—	23	63
(B)	1	—	—	—	4	7	31	17	1	—	39	81
Five Islands, I, II—												
(A)	—	—	—	—	5	11	32	27	2	—	23	44
(B)	2	—	—	—	4	9	26	21	2	—	36	57
Five Islands, III—												
(A)	—	—	—	—	11	5	52	21	—	—	11	19
(B)	5	—	—	—	9	5	45	18	—	—	18	22
Five Islands, IV—												
(A)	—	—	—	—	8	8	50	13	—	—	21	38
(B)	2	—	—	—	6	6	43	11	—	—	32	47
Five Islands, V—												
(A)	—	—	—	—	0	8·5	50	8·5	—	—	33	12
(B)	—	—	—	—	0	6	44	6	—	—	44	16
Brush Island—												
(A)	—	1·5	—	11	8	13	30	28	1·5	—	7	61
(B)	—	1·5	—	10	8	12	27	26	1·5	—	14	66
Eucalyptus pilularis Association in Bulli District. (B)	—	2	10	7	15	12	12	24	9	—	9	82
'Normal' Spectrum ..	1	3	6	17	20		9	27	3	1	13	400

(A), indigenous species; (B), total species.

S, stem-succulent; E, epiphyte; MM, mega- and meso-phanerophytes; M, microphanerophyte; N woody nanophanerophyte; N', other nanophanerophytes (perennial herbs or climbers with growing apex reaching more than 1 foot in height); Ch, chamaephyte; H, hemicryptophyte; G, geophyte; HH, halo- and hydro-phytes; Th, therophyte.

TABLE 5.
Introduced Plants.

	Number of Introduced Species.	Percentage of Species Introduced.	Life-Forms of Species Introduced.	Means of Entry of Species Introduced.
Five Islands **I-V** ..	18	22	S 1, Ch 1, Th 16	W 9, F 2, FF 1, X 6
Five Islands, **I**, **II** ..	13	23	S 1, Ch 1, Th 11	W 7, F 1, FF 1, X 4
Five Islands, **III** ..	3	14	S 1, Th 2	W 2, FF 1
Five Islands, **IV**	9	19	S 1, Ch 1, Th 7	W 5, F 1, FF 1, X 2
Five Islands, **V** ..	4	2·5	Ch 1, Th 3	W 1, F 1, X 2
Brush Island	5	8	Th 5	W 3, F 1, X 1

For Life-Form abbreviations, see explanation to Table 4.

Means of entry: W, plumed fruit, wind-borne; F, fleshy fruit; FF, fleshy fruit and floating cladode; X, other means.

EXPLANATION OF PLATES XV-XIX.

Plate xv.

Vertical aerial photographs of the Five slands, scale 10 inches to the mile. A, Islands **I**, **II** and **III**; B, Island **IV**; C, Island **V**. For orientations see Plate xv*a*; for relative positions see Text-figure 1. Sun in approximately north-eastern position; half-tide. July, 1937. Photographs by Adastra Airways Pty., Ltd.

Plate xv*a*.

Outlines of principal communities of vascular plants. For all the islands, bare igneous rock is represented as black. In the transparency to Pl. xv, C (Island **V**), the white areas represent all areas occupied by vascular plants, which are very restricted and scarcely form definite communities. For the other islands, the following symbols are used for the various communities:

Plain white, *Stenotaphrum* community (*Phytolacca* facies with small crosses, *Tetragonia* facies with small black triangles); small circles, *Correa-Westringia* community; tussock symbols, *Scirpus nodosus* community; stippling, *Sporobolus* community; broken diagonal lines, *Mesembryanthemum* community; vertical shading, *Salicornia* community; heavy asterisks, *Lomandra* community; horizontal shading, *Spergularia-Claytonia-Portulaca* community; cross-hatching, loose sand.

Plate xvi.

Vertical aerial photograph of the Five Islands (**I**, **II** and **III**), Midway Reef, and the adjacent coast. Scale 4 inches to the mile. Sun in approximately north-western position; half-tide. August, 1937. Photograph by Adastra Airways Pty., Ltd.

Plate xvii.

A.—Camp Hummocks, **I**: Dune sand held at old level by *Stenotaphrum secundatum* (left) and *Lomandra longifolia* (right); sand elsewhere removed by wind action ('blow-out') to level of underlying recent sandstone. *Scirpus nodosus* tussocks growing in shallow sand accumulations at new level.

B.—Tussocks of *Lomandra longifolia* holding dune sand at old level, north-eastern part of **I**. *Scirpus nodosus* tussocks growing in very shallow soil collected around their bases; 'blow-out' area otherwise devoid of soil.

C.—North-eastern side of **I**. from the west end of **II**, showing drifts of sand removed from the top of **I** by wind action. The area so denuded is visible immediately above the large sand-drift, and to the right of the denuded area Camp Hummocks are seen on the upper parts of the island, where the vegetation has held the sand against erosion.

D.—'Blow-out' area, centre of **I**. Removal of the dune cover has exposed recent sandstone, which has weathered to an irregular surface by water action. Soil absent except for shallow accumulations of sand around tussocks of *Scirpus nodosus*; old shells (*Turbo* *stramineus* Gmel., *Cymatium spengleri* Perry) from an aboriginal kitchen-midden have been left behind when the sand around and below them was blown off.

E.—Erosion of recent sandstone exposed by removal of sand cover, west of Periwinkle Point, **I**. *Scirpus nodosus* tussocks growing as in A, B and D.

F.—Portion of area shown in figure E, where water action has cut through the recent sandstone, exposing a clay soil. This clay is probably the illuvial horizon of a doleritic soil pre-dating cover of the area by dunes. *Mesembryanthemum aequilatcrale* growing on left side of cutting.

G.—Bushes of *Correa alba* and *Westringia rosmariniformis,* with *Sporobolus virginicus* in foreground. East end of **II**.

H.—Bushes of *Westringia rosmariniformis,* south end of plateau, **IV**.

I.—Plateau of **IV**, looking north from near southern end. *Mesembryanthemum* community and bushes of *Correa* and *Westringia* in the background, and *Myoporum ellipticum* facies of shrub community on left.

J.—The beach, **I**: *Stenotaphrum secundatum,* with lower limit only 8 feet above mean tide level. Exposed sand with vegetation disturbed by burrows of sea-birds visible in central background. The boat is 16 feet long.

Plate xviii.

A.—Between the beach and Camp Hummocks, **I**: Permanent quadrat in portion of *Stenotaphrum* community disturbed by burrowing activities of sea-birds; looking north-east. Corners of quadrat (side 10 ft.) indicated by black rings. Bushes of *Phytolacca octandra* to the left. Date 18/12/37.

B.—Quadrat of figure A, 24/4/38. Bushes of annual *Phytolacca octandra* dead; about two inches of the surface sand removed by wind action, the isolated patch of *Stenotaphrum* near the centre of the quadrat partly undermined thereby.

C.—North side of **II**, near west end: Large expanse of *Opuntia inermis* killed by poisoning, March, 1936.

D.—*Opuntia* regenerating: Same locality as figure C, August, 1937.

E.—*Opuntia* regenerating: Living cladodes and dead remains, west edge of plateau, **IV**.

F.—*Sporobolus* community, near east end of **II**; on the left, the soil has been blown off, exposing the underlying dolerite. The stick is 1 metre high.

G.—Dense growth of *Scirpus nodosus*, 'blow-out' area near High Hummock, **I**.

H.—*Mesembryanthemum* community, surrounded by *Sporobolus* community, on the higher parts of the west end of **III**. The note-book is 8 inches high.

I.—Central part of plateau, **IV**, March, 1936: *Stephania hernandifolia* with *Plectranthus parviflorus* and species of Compositae. *Correa* and *Westringia* bushes in background.

J.—The same, March, 1938: *Mesembryanthemum aequilaterale* has largely displaced *Stephania*, etc.

Plate xix.

A.—*Salicornia* community, in depression on south side of **III**, near west end. *Sporobolus* and *Mesembryanthemum* communities in background. The note-book is 8 inches high.

B.—*Portulaca oleracea* growing in moist shallow soil in rock-basins, eastern slopes of **IV**.

C.—Gulls (*Bruchigavia novae-hollandiae*) nesting on the western end of **III**; vegetation *Sporobolus virginicus* with *Opuntia*.

D.—Triangle Pool, **II**: A brackish pool 29 ft. above mean tide level.

E.—Freshwater Springs: Holes dug in the soil of the *Stenotaphrum* community, behind and to the south of the beach, **I**; about 28 ft. above mean tide level, with almost fresh water.

F.—Pool in hollow in the dolerite, Periwinkle Point, **I**. Elevation 40 ft. above mean tide level, but with high salinity, due to infrequent overflow and heavy incidence of spray. Periwinkles (*Nodilittorina tuberculata*) occur in and around this pool.

G.—Phragmites Soak, **I**: A pool at the bottom of the sand-drift, through which water percolates. Although less than 25 ft. above mean tide level, constant run-off ensures low salinity of the water. The vegetation of the sand-drift is *Stenotaphrum secundatum* (with stolons hanging down over the rocks), and *Phragmites communis*. The note-book is 8 inches high.

H.—A pool below that shown in the preceding figure, with slightly higher salinity. *Scirpus cernuus* (in rectangle) growing in wet sand in pool, *S. nodosus* in drier situation above. The characteristic crevices in the dolerite are apparent in this photograph.